Forest Health Conditions

in

Wisconsin

Annual Report

1999

Compiled and Edited by

Forest Health Protection Staff

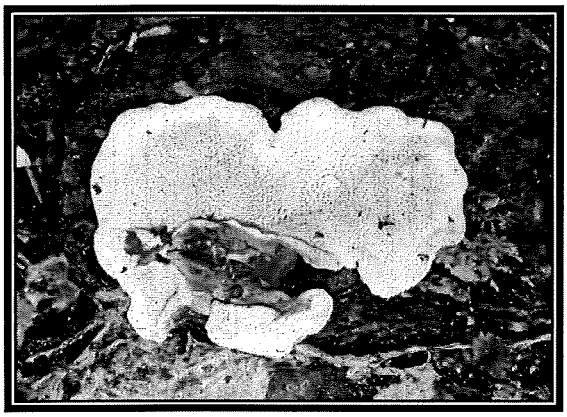
Wisconsin Dept of Natural Resources

PO Box 7921

Madison, WI 53707

Annosum root rot – *Heterobasidion annosum* (*syn. Fomes annosus*)

First observed in Wisconsin in 1993, Annosum root rot has now been found killing red pine in the following four counties: Adams, Iowa, Richland and Sauk. Annosum root rot has a worldwide distribution and is considered one of the most damaging diseases to plantation-grown conifers. In Wisconsin, red pine, jack pine, white pine and white spruce are likely to be the species that are most susceptible to this disease. New infections occur when wind-blown spores of the fungus land on freshly cut stumps or other root and stem wounds. Applying Sporax (a pesticide registered for preventing stump infection) can prevent infection to freshly cut stumps. See page 18 for more information on Annosum and Sporax.



Underside of Annosum Fruit-Body

Forest health protection staff are concentrating their efforts on surveys to locate additional infections and conducting a pilot biological control in Iowa County.

Please be on the look out for signs of Annosum root rot. Page 18 of this document shows what signs to look for. Please report any observations of Annosum root rot to your DNR regional forest health specialist.

Proportion of Forest Land and Timberland

The area of forestland in Wisconsin has been steadily increasing in recent decades and currently stands at almost 16.0 million acres, representing 46% of the total land area. The state now has the most forest land it has ever had at any time since the first forest inventory in 1936. Wisconsin's forests are predominately hardwoods, with 84% of the total timberland area classified as hardwood forest types. The primary hardwood forest type in the state is maple-basswood (Figure 1), which makes up 5.3 million acres (34%) of Wisconsin's timberland area. Conifer types represent 16% of the total timberland area (pine forests - 8%, spruce-fir - 6%, and swamp conifers - 2%).

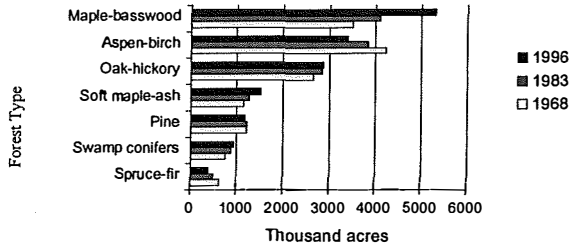


Figure 1. Area of timberland (in thousand acres) by forest type for 1983 and 1996. Data taken from 1996 FIA survey.

Wisconsin timberland increased by 940,000 acres between 1983 and 1996.

- 1968 - 14.54 million acres
- 1983 - 14.76 million acres
- 1996 - 15.70 million acres

Timberland is defined as forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development.

Ownership of Wisconsin's Timberland

Individual private landowners are the largest group of timberland owners in Wisconsin, owning 57% of all timberland in 1996 (Figure 2). counties and municipalities are the largest group of public owners, holding 15% of the total area of timberland in Wisconsin. The percentages of ownership have remained relatively constant since the forest inventory in 1956.

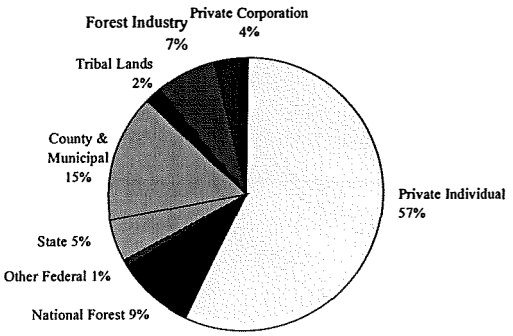


Figure 2. Ownership of Wisconsin's forests. Data taken from 1996 FIA survey.

Growing-stock Volume of Wisconsin's Timberland

Growing-stock volume on timberland in Wisconsin increased from 16.5 billion cubic feet in 1983 to 18.5 billion cubic feet in 1996 (Figure 3), reflecting an increase in both area and stocking during the 13 years between inventories. In both 1983 and 1996, hardwoods accounted for ¾ of all growing-stock volume.

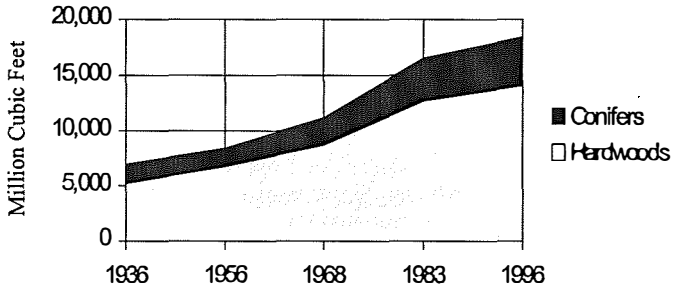


Figure 3. Growing stock volume (in million cubic feet) on timberland in Wisconsin, 1936-1996. Data taken from 1996 FIA survey.

Most Common Species Groups of Wisconsin's Timberland

The species groups with the most growing-stock were aspen, red oak, hard maple, and soft maple (Figure 4). The conifer species groups with the most growing-stock in 1996 were red pine and white pine.

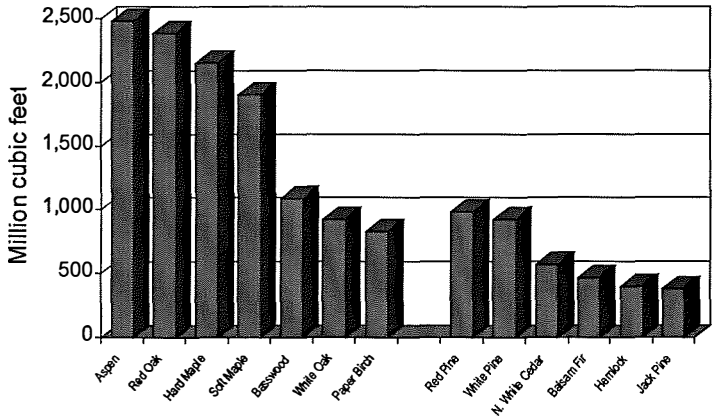
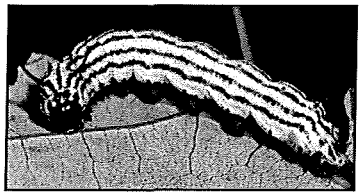


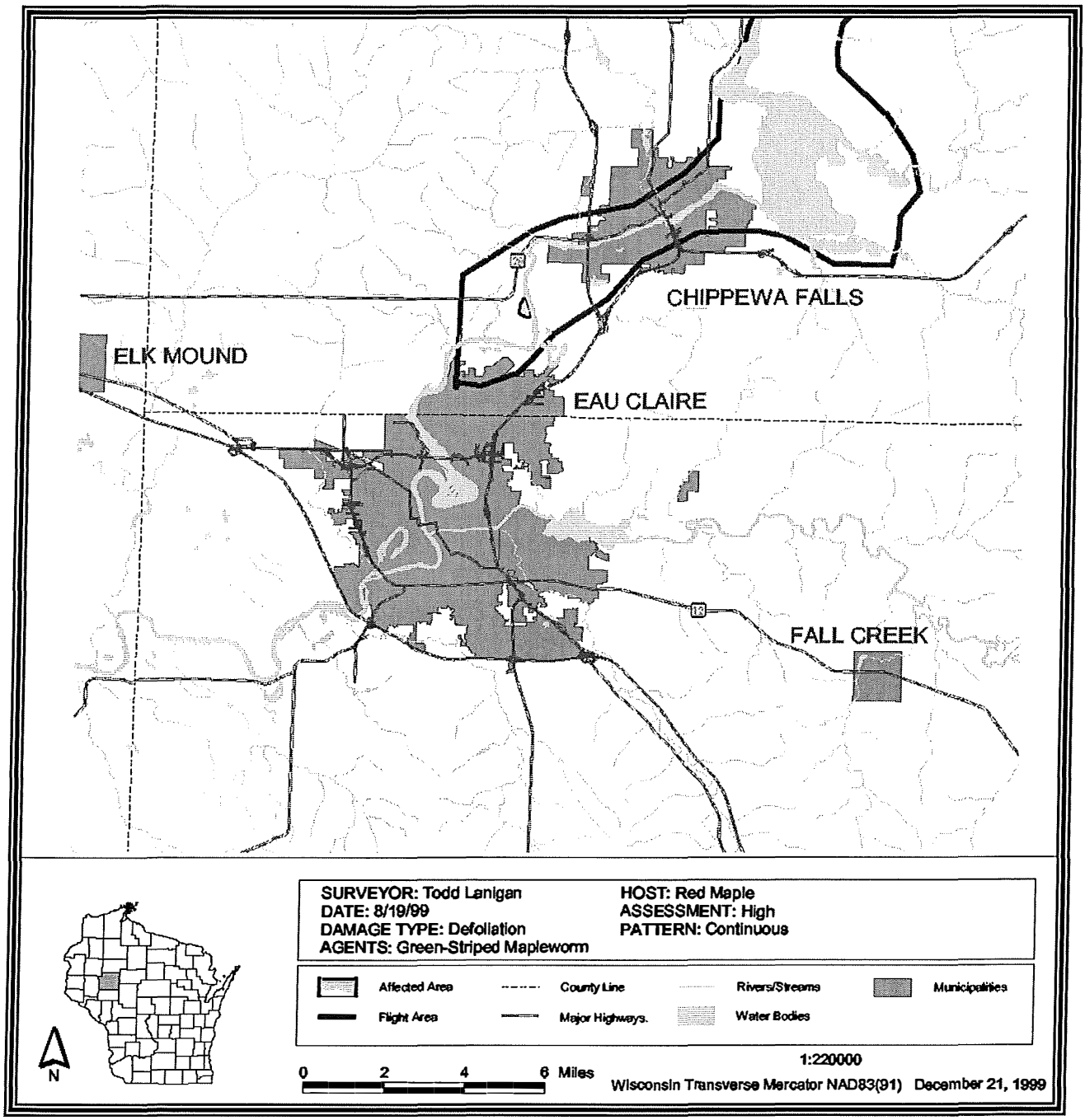
Figure 4. Most common hardwood and conifer species (in million cubic feet) on timberland in Wisconsin. Data taken from 1996 FIA survey.

Major Pests of 1999

Green-striped Mapleworm *(Dryocampa rubicunda rubicunda (Fabricius)*

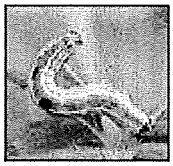


The green-striped mapleworm caused heavy defoliation of red maple in Chippewa and Washburn counties, though populations are declining in most of northwestern Wisconsin. The mapleworm defoliates hardwood stands, particularly maple, during July. The caterpillars can become so abundant on maple trees that they completely strip the leaves. Serious injury can follow several years of defoliation. Boxelder and oak may be defoliated severely, particularly when mixed with maple.

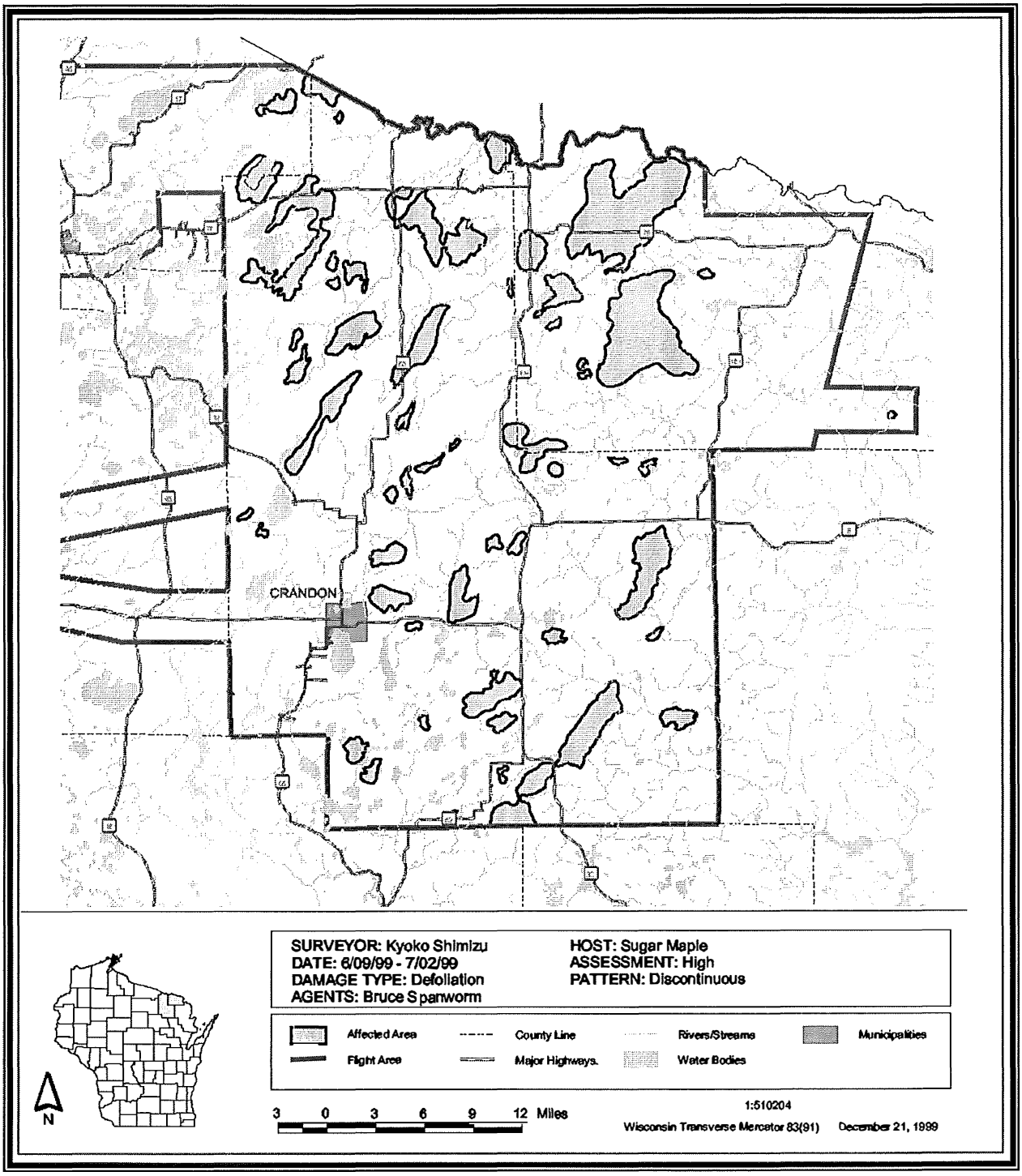


Green-Striped Mapleworm defoliated 67 acres of red maple in Chippewa County – 1999

Bruce Spanworm *(Operophtera bruceata (Hulst)*

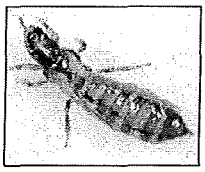


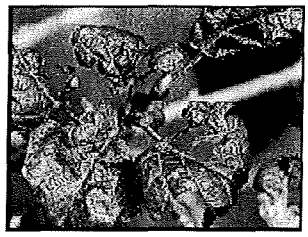
The Bruce spanworm, *Operophtera bruceata (Hulst),* caused moderate to severe defoliation of sugar maple in Forest, Vilas, and Florence counties again this year and, for the first time, in Menominee County. Although feeding had ended by the end of May, some trees were completely defoliated. Areas of defoliation from last year appear to have spread in 1999. The only previous outbreak by this insect in Wisconsin occurred from 1984 to 1987. The Bruce spanworm is a native insect that feeds on several species of deciduous trees, but has become an important pest of maple stands in Wisconsin.



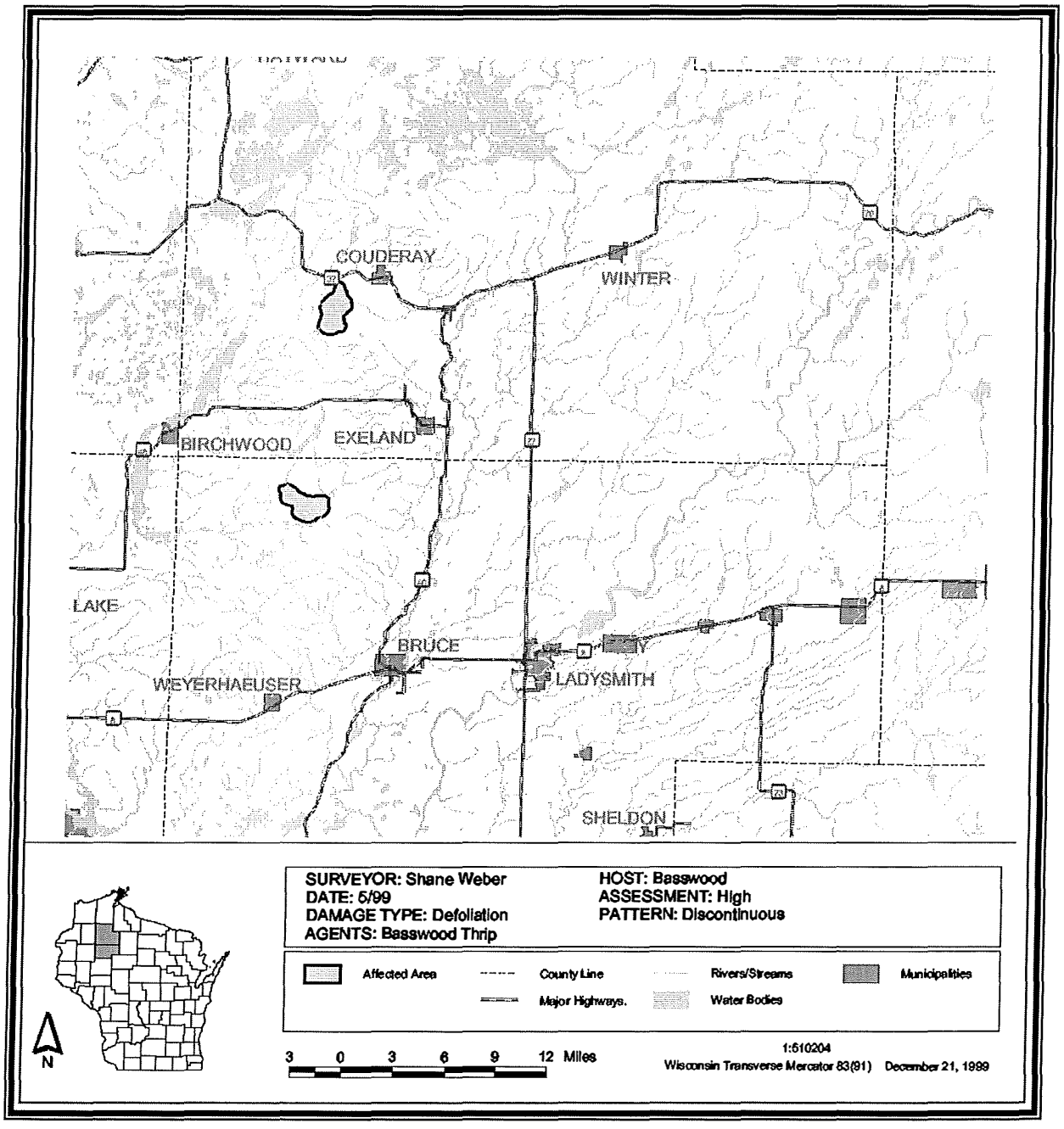
The Bruce Spanworm defoliated 68,864 acres in Forest County, 2,510 acres in Vilas County, and 42,627 acres in Florence County in 1999.

Introduced basswood thrips *(Thrips calcaratus)*



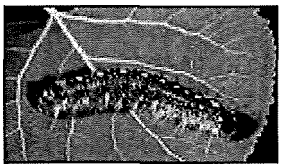


Thrips calcaratus, are a recently recognized defoliator of American basswood in the Lake States. Over the past several years, basswood stands in northern forests have suffered moderate to severe defoliation. Damage can resemble early spring frost injury (figure on right), but examination of the newly expanding leaves reveals small, active insects. Although populations of introduced basswood thrips were down from last year in northwest Wisconsin, moderate to severe defoliation was seen in Forest, Florence, Lincoln, and Oneida counties.



Basswood Thrips defoliated 2,600 acres in Rusk County and 2583 acres in Sawyer County- 1999

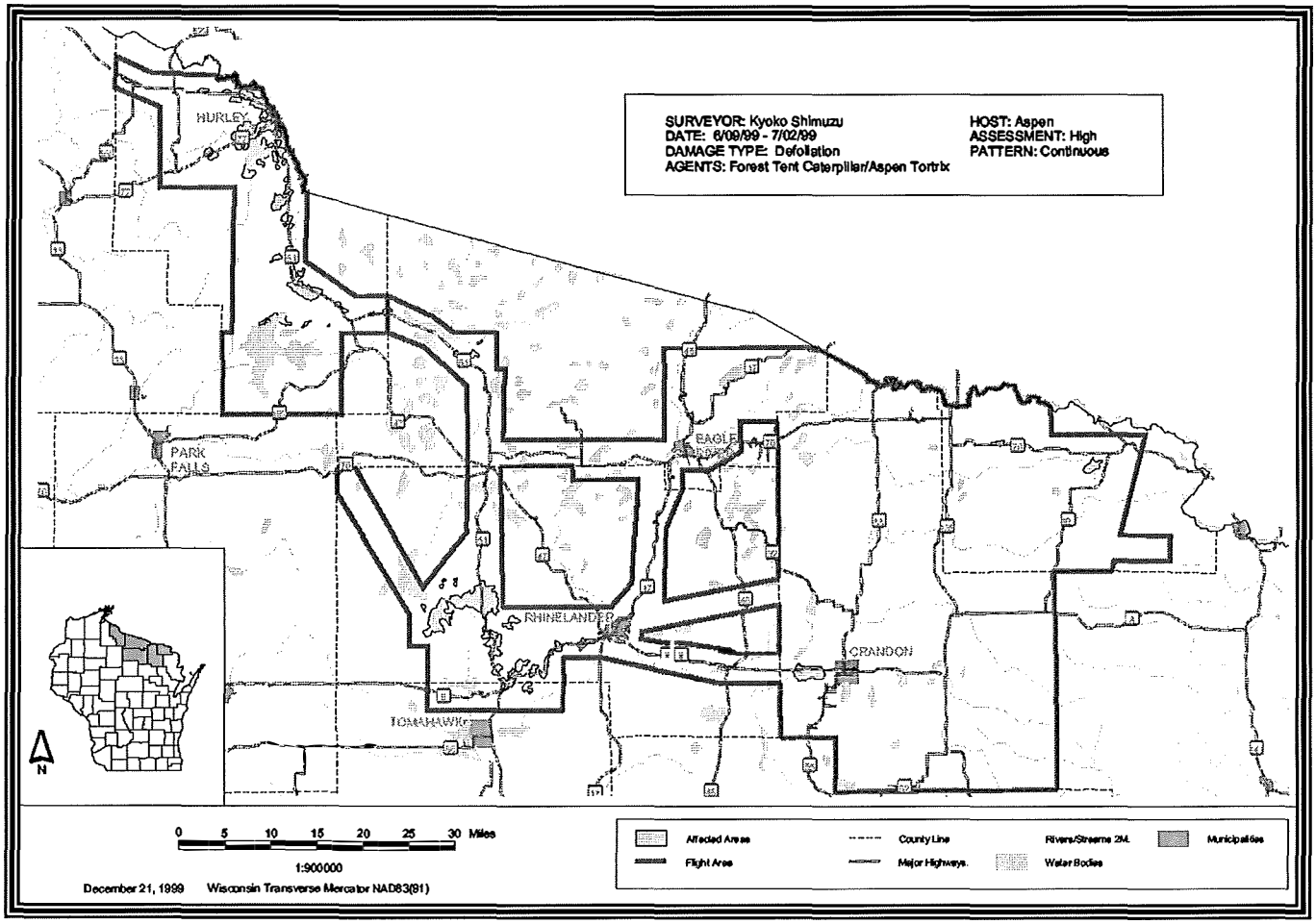
Aspen Defoliation: Forest Tent Caterpillar (*Malacosoma disstria* Hubner)
Large Aspen Tortrix *(Choristoneura conflictana* Walker)



The **forest tent caterpillar** (*Malacosoma disstria* Hubner) may be found throughout the United States and Canada wherever hardwoods grow. It is a native insect that has attracted attention since colonial times. Regionwide outbreaks have occurred at intervals varying from 6 to 16 years in northern areas. The favored hosts of this insect are sugar maple and aspens in the Lake States. Other tree species fed upon include birch, cherry, basswood, and ash. Species not fed upon are red maple, sycamore, and most conifers. Outbreaks in the Lake States typically last for 3 years, then subside. Diameter growth may be reduced as much as 90 percent. Such defoliation kills few trees except for those that are suppressed. Populations of forest tent caterpillar were on the rise in northern Wisconsin. Scattered pockets of mostly aspen and some oak defoliation occurred from St. Croix in Polk County to Minoqua in Vilas County. Defoliation was more prominent in the eastern part of this region.

In Florence and Oneida counties, this was the second year of defolation caused by the **large aspen tortrix** (***Choristoneura conflictana*** Walker), but the area affected was smaller and defoliation was lighter than in 1998.

The 2 pests defoliated 22,088 acres in Iron County, 893 acres in Lincoln County , 19,871 acres in Oneida County, 1,703 acres in Vilas County, 1,573 acres in Florence County, and 2,765 acres in Forest County.



Locations of defoliation of Aspen caused by Forest Tent Caterpillars and Aspen Tortrix - 1999

Oak Anthracnose and "Tatters"

Over the past 4 years, **white and bur oaks** have been the victim of leaf pathogens, insects and weather-related injuries. Any of these injury-causing agents by themselves or occurring on an occasional basis are not significant yet several of these factors have been occurring together for the past 4 years. During the spring of 1999, **anthracnose** and **tatters** were widespread in south-central and southern Wisconsin. Observations of trees that have been affected by these and other injury-causing factors reveal branch dieback in the upper and outer crown. Continued injury by these pests is likely to induce further decline and mortality of white and bur oak in southern Wisconsin.

The cool, wet weather of 1999 provided perfect conditions for the fungus *Discula sp.* to cause widespread leaf blight or **anthracnose**. White oak was the species most commonly affected. Symptoms of anthracnose include chlorosis and necrosis of the leaf margins and in spots along the leaf veins. Heavily infected leaves turned completely brown and hung on the tree in small, curled bunches. Refoliation or the production of new leaves was common in late June; new leaves were unaffected.

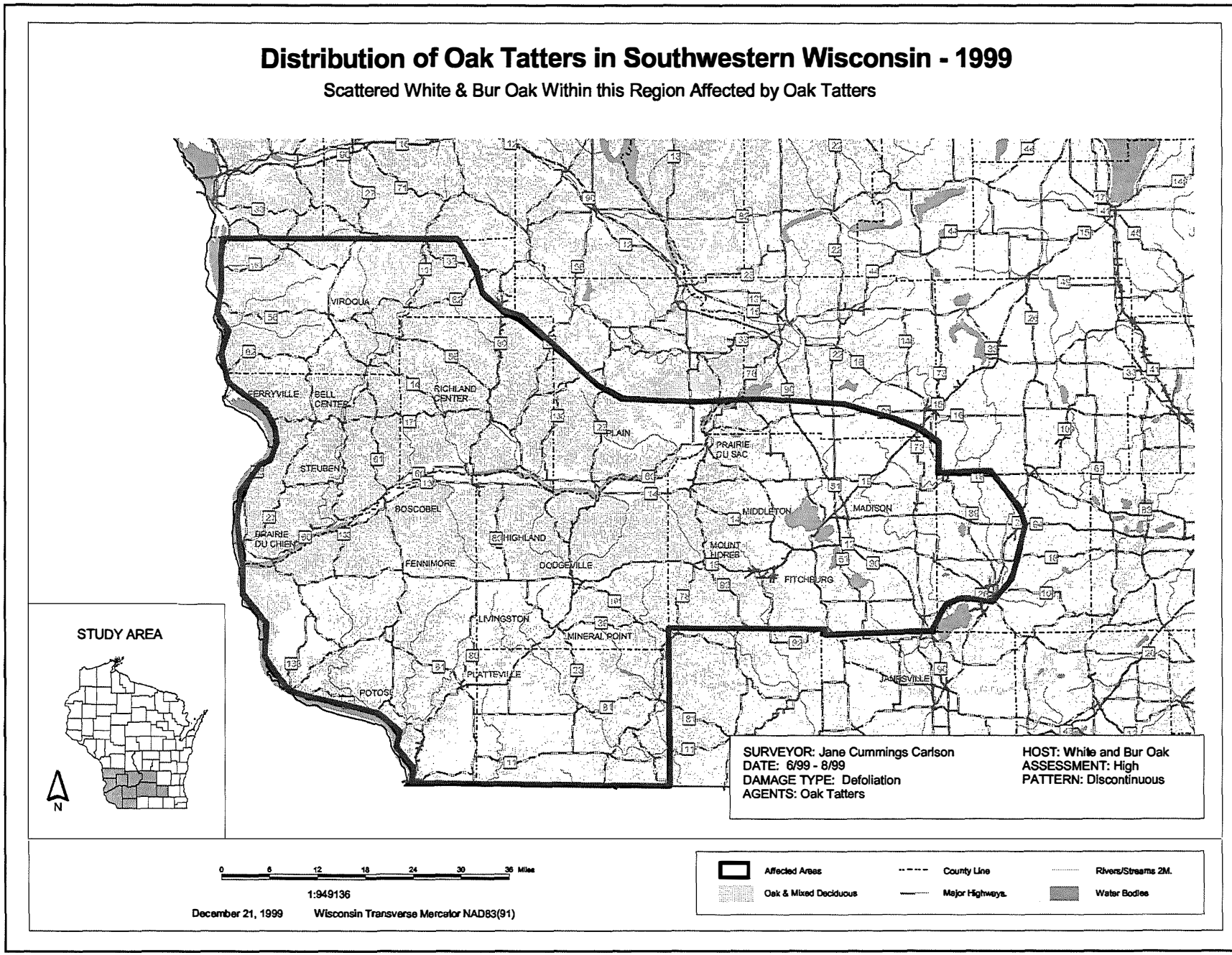
Several differences between anthracnose and oak wilt are worth noting.

1. Oak anthracnose is most severe on white oak, whereas oak wilt is most severe on oaks in the red oak family.
2. Oak anthracnose produces irregular spots/blotches randomly over the leaf. Spots may coalesce forming large brown areas. In addition, leaves may be curled or deformed along the outer margins of new growth.
3. When leaves are dying as a result of oak wilt, browning generally begins at the margins of leaves, resembling symptoms of drought. This is due to blockage of water and nutrients in the vascular tissue preventing these nutrients and water from reaching the leaves.
4. Symptoms of oak anthracnose are most severe on the lower, inside branches where humidity levels are higher. Symptoms of oak wilt begin on branch extremities, usually in upper portions of the tree.

Oak tatters has become a moderately common and recurring problem in the spring. Both white and bur oak produced small, torn and "tattered" leaves in south-central and southwestern Wisconsin in 1999.

Affected oak leaves have a deformation that is distinctive - most of the leaf tissue which should be present is missing. Usually there is a thin strip of leaf tissue remaining along the major veins. Furthermore, the leaves often appear to have been stretched. This combination of thin strips of leaf tissue and stretched leaves give the foliage a strap-like appearance and the tree canopy a thin, lacy appearance.

Trees with severe damage produce a new crop of foliage in a few weeks but several years of damage may lead to tree mortality. Although no single cause is known, cool temperatures or high winds at the time of bud expansion may contribute to the occurrence of oak tatters.



Distribution of Oak Tatters in Southwestern Wisconsin - 1999

Windstorm Damage Initial Assessment: July 1999

Don Monson, Forestry Specialist, Spooner, WI
Gary Vander Wyst, Assistant Regional Forestry Expert, Rhinelander, WI

On July 4, 1999, a windstorm caused major damage to forests in Minnesota and affected a small section in northwest Wisconsin. A 12 mile swathe or about 1,000 acres was blown down in Highland township, Douglas County and Barnes township in Bayfield County (see map on page 16). The area affected was evenly divided between Bayfield County property and Mosinee Industries.

On July 31, 1999, a windstorm traveled through southern Douglas County and into southwestern Bayfield County. The path of the storm covered approximately 100,000 acres. Within that broad path there were areas of forested land that received only minimal damaged and while other patches of forested land were entirely flattened or had trees heavily damaged.

Blowdown west of Flynn Lake SPNM area on the Chequamegon National Forest, Bayfield County.

The following assessment is limited to the flattened or heavily damaged areas of the storm.

Bayfield County

The timber damaged in Bayfield County on US Forest Service and industrial lands will be salvaged by commercial logging operations. The timber on private lands may be salvaged by commercial logging if the landowner is made aware of that option and has enough volume on their individual ownership to attract a logger. The DNR Foresters at Barnes are contacting private landowners to make them aware of the damage and of loggers and consultant foresters who will help the landowners salvage the damaged timber on their property. There was an additional 8,000 acres of private forest land in Bayfield County that received light damage. No estimate of damage available.

Table 1. Acreage, volume and value of timber blowdown in Bayfield County.

Ownership	Estimated Acres Damaged	Estimated Volume of Timber Damage	Estimated Value of Timber Damaged
US Forest Service	10,000	52 Mmbf	$4,200,000
Industrial Forest – Nekoosa (GP)	1,200 1,800	24,000 cords Jack Pine 36,000 cords Red Pine	720,000 1,080,000
Industrial Forest – Mosinee	700	14,000 cords Red Pine	420,000
Private Lands	4,000	56,000 cords Aspen 24,000 cords Jack Pine	$1,120,000 720,000
Total	**16,700**	**52Mmbf** **154,000 cords**	**$8,260,000**

Douglas County

The timber damaged on industrial lands in Douglas County will be salvaged by commercial logging operations. The timber damaged on the Brule River State Forest annex near Gordon is in the process of being offered for sale to loggers for commercial salvage. The Douglas County timber is in the process of being salvaged by commercial logging. The private lands may be salvaged by commercial logging if the landowner is made aware of that option and has enough volume on their individual ownership to attract a logger. The DNR Foresters at Gordon and Barnes are contacting private landowners to make them aware of the damage and of loggers and consultant foresters who will help the landowners salvage the damaged timber on their property. There was an additional 21,000 acres of private forest land in Douglas County that received light damage. No estimate of damage available.

Table 2. Acreage, volume and value of timber blowdown in Douglas County.

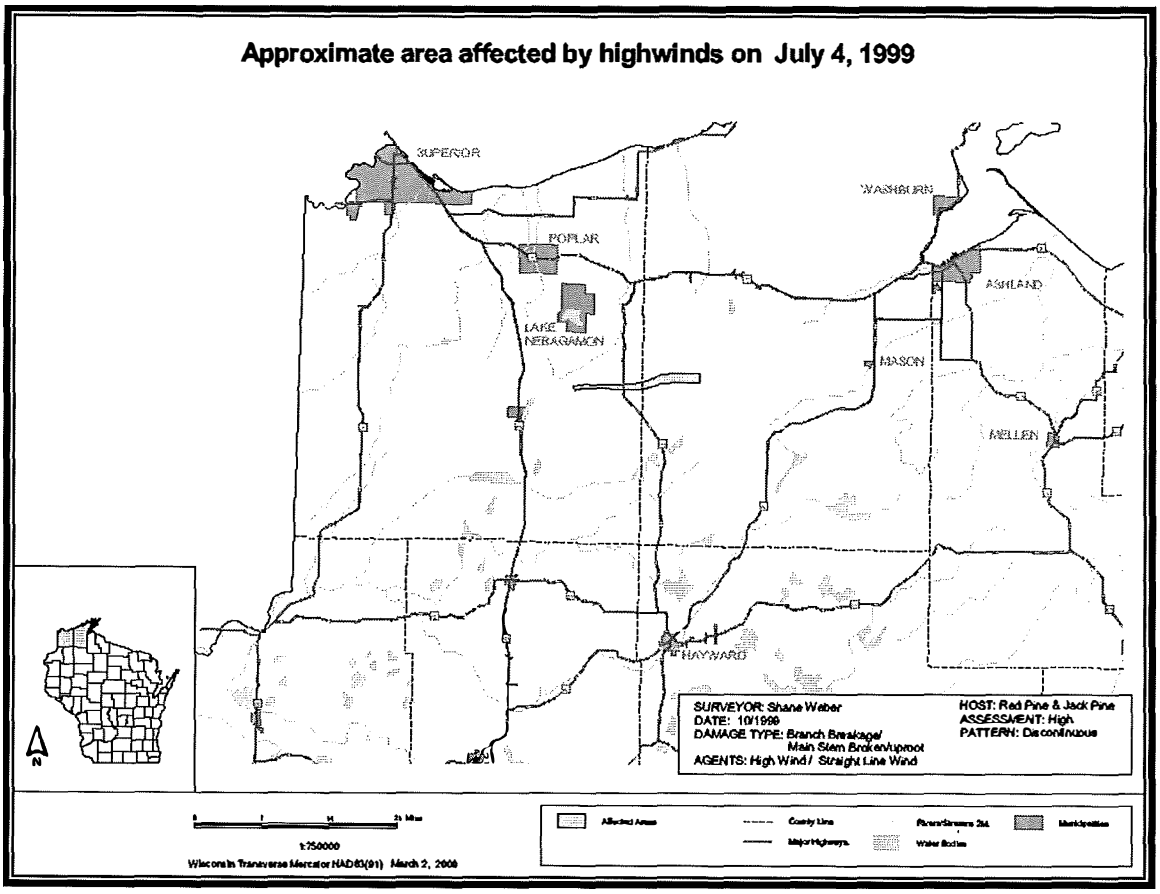
Ownership	Estimated Acres Damaged	Estimated Volume of Timber Damaged	Estimated Value of Timber Damaged
Industrial Forest - Mosinee	7,200	144,000 cords Jack Pine and Red Pine	$4,320,000
Industrial Forest – Nekoosa (GP)	400	8,000 cords Jack Pine and Red Pine	240,000
Industrial Forest – Other	300	6,000 cords Jack Pine and Red Pine	180,000
Brule River State Forest	500	10,000 cords Jack Pine and Red Pine	300,000
Douglas County Forest	700	14,000 cords Jack Pine and Red Pine	420,000
Private	2,500	15,000 cords Jack Pine 25,000 cords Aspen 10,000 cords Red Pine	450,000 500,000 300,000
Total	**11,600**	**232,000 cords**	**$6,710,000**

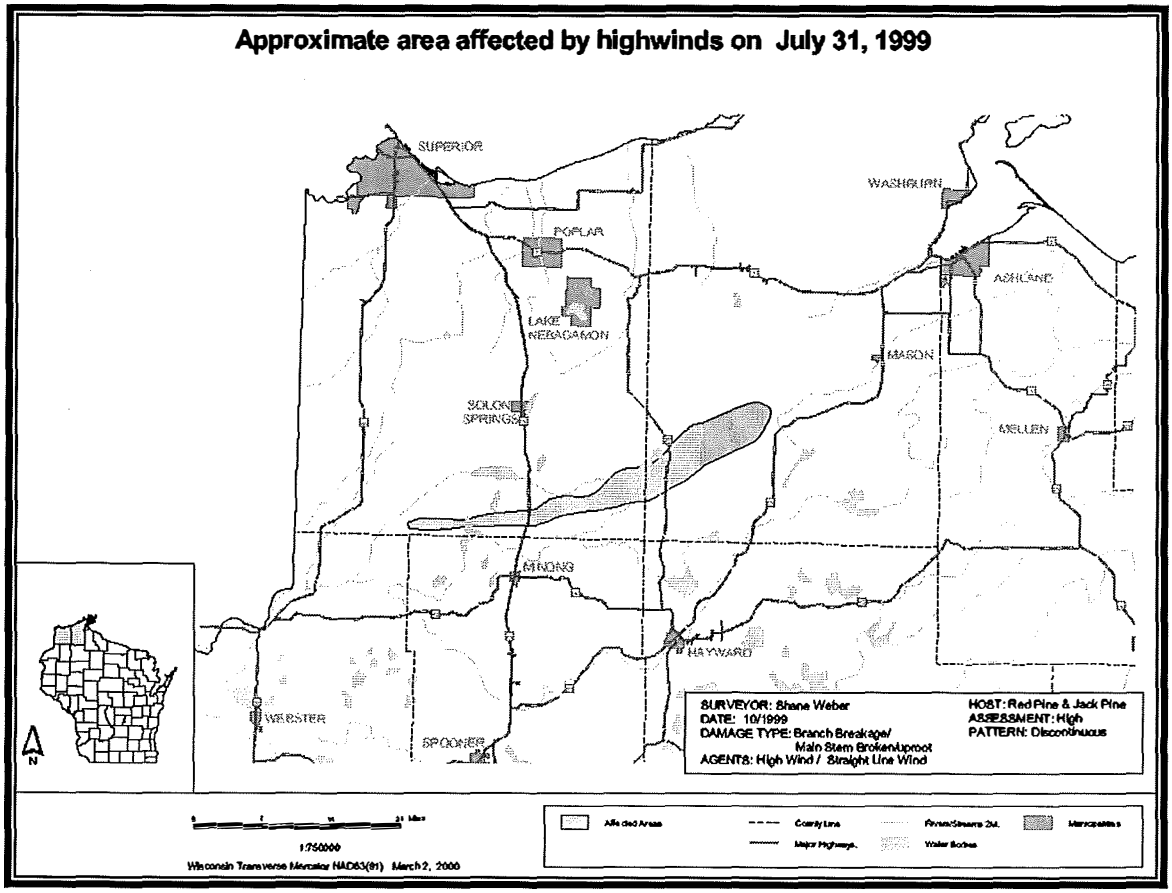
Vilas & Oneida counties

The timber damaged in Vilas and Oneida counties will be salvaged by commercial logging operators. Sales on private lands may be salvaged by commercial operators if there is sufficient volume in conjunction with adjacent landowners. Total estimated damage for Oneida, Vilas and Rusk counties is 5,000 to 6,000 acres of heavy damage, between 7,500 to 10,000 acres of light to no damage.

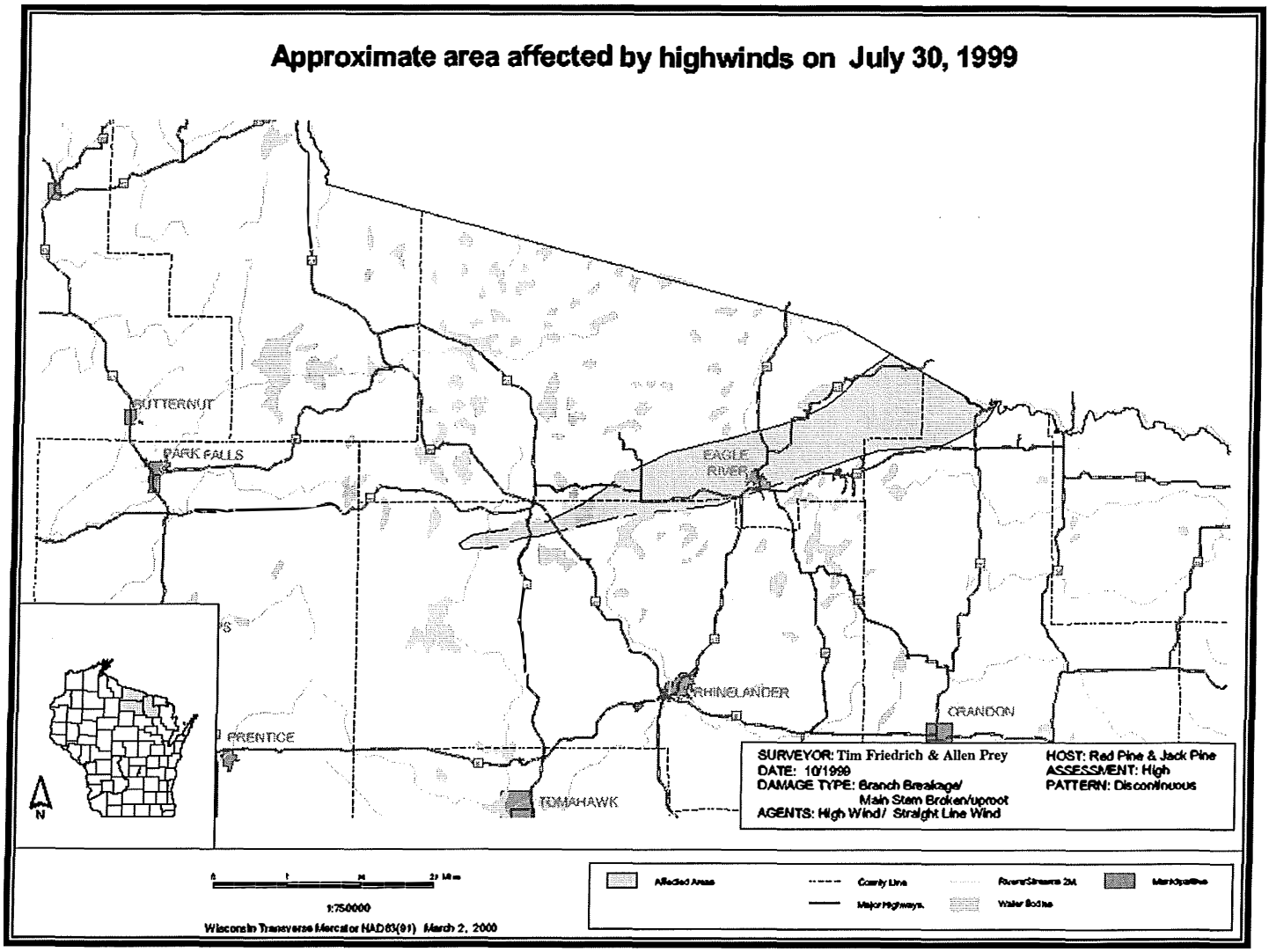
Table 3. Acreage, volume and value of timber blowdown in Vilas and Oneida counties.

Ownership	Estimated Acres Damaged	Estimated Volume of Timber Damaged	Estimated Value of Timber Damaged
US Forest Service Eagle River/Florence	389	2.8 MMBF	$ 200,000
NH/AL State Forest	3,120	40,000 cords Red Pine 22,400 cords Aspen	1,280,000 380,800
Private	840	8,000 cords Red Pine 8,000 cords Aspen	256,000 136,000
(Rusk Co) (40 Ac)	--	.12 MMBF	18,000
Other State Lands	150	1,500 cords Red Pine 1,500 cords Aspen	48,000 25,500
Vilas Co. Forest	200	2,000 cords Red Pine 2,000 cords Aspen	64,000 34,000
Total	**4,699**	**2.92 MMBF 85,400 cords**	**$2,442,300**





Blowdown areas in Douglas and Bayfield counties occurring on July 4 (upper) and July 31 (lower).



Path of July 30th windstorm in Vilas, Forest and Oneida counties.

Annosum Root Rot – *Heterobasidion annosum*

Signs, Symptoms, and Management

WI DNR Forest Health Protection - 1999

Introduction/Symptoms:

First observed in Wisconsin in 1993, Annosum root rot is now known to occur in Adams, Iowa, Richland and Sauk counties (Figure 1).

"Infection centers" or areas where Annosum root rot has been active may contain one to many dead trees surrounded by recently dead or dying trees (Figures 2,3). Dying trees usually have thin crowns and reduced shoot growth.

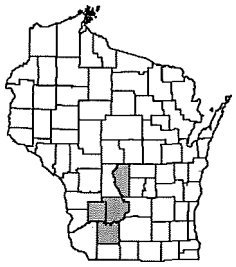


Figure 1. Known locations of Annosum root rot, 1999.

Biology:

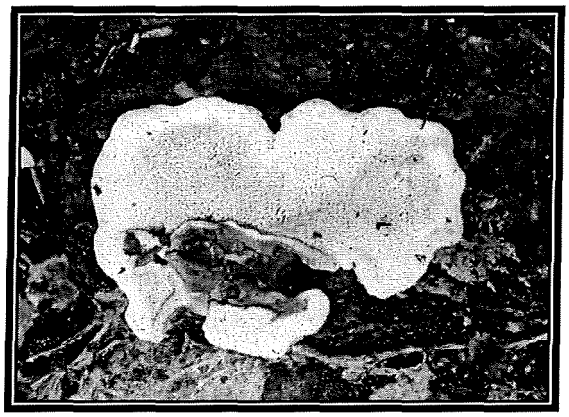
Infection most often occurs through freshly cut stump surfaces but can occur through fresh root and stem wounds. Red, jack, and white pine and white spruce are the species most likely to be infected in Wisconsin. Once the stump is infected, the fungus grows into the root system and spreads underground from tree to tree through connected roots. Infection is most likely to occur in the spring and fall when Annosum produces spores; the exact timing is still under investigation. Observations of Annosum pockets in southern Wisconsin show new mortality of red pine along the edges of the pocket each year. Root rot pockets are ideal locations for bark beetles to become established because diseased trees are under stress.

Figure 2. Annosum root rot pocket or infection center. Note the red pine that has been dead for several years; its top has broken off. The recently dead red pine in the background has a very thin crown and discolored foliage.

Figure 3. Annosum root rot pocket. Note progression of mortality into the stand and the understory filling in with woody shrubs.

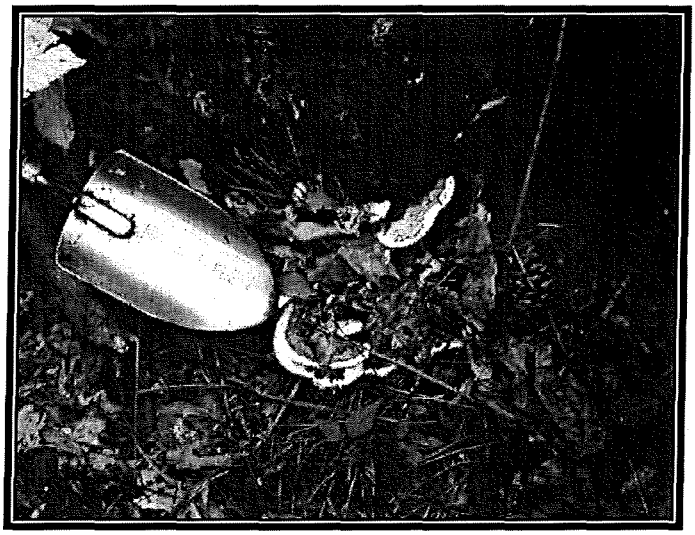
Signs:

Annosum fruit-bodies or conks (spore-producing structures) are most commonly observed in the fall, but occasionally may be observed in the spring. They are perennial, but can disintegrate quickly and thus may appear annual. Fruit-bodies vary in color but are usually light to dark brown above and white to tan below. Young basidiocarps look like small white popcorn.



Underside of Annosum Fruit-Body

Top of Annosum Fruit-Body



A Cluster of Annosum Fruit-Bodies

Management:

Prevention is the key to minimizing mortality caused by Annosum root rot.

1. Time thinnings during the coldest and driest part of winter, when spore production is likely to be low.
2. Minimize the number of felling and skidding wounds.
3. Treat all fresh red pine stumps with Sporax immediately after felling.[1] Sporax or sodium tetraborate decahydrate is effective in preventing establishment and growth of *Heterobasidion annosum* in cut stumps of conifers that are not already colonized.
4. Favor hardwoods on sites where disease is widespread.
5. During harvest, remove infected material from the stand. Infected trees, lying on the forest floor, may produce additional fruit-bodies.
6. Monitor for the development of bark beetle pockets and consider a sanitation cut if populations of bark beetles start building.

***** Report all possible sightings of Annosum root rot to a DNR Forest Heatlh Specialist or to Jane Cummings Carlson, 608-275-3273; cummij@dnr.state.wi.us**

[1] Sporax is available in 25-pound bags from the Wilbur-Ellis Company, 13771 South Prescott Road, Manteca, CA 95336. Phone: 1-800-982-4337; website: www.wilbur-ellis.com

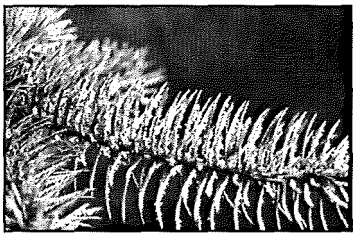
Needlecast on White Pine

In April and May of 1999, **chlorosis and casting** of 1998 needles occurred on **white pine** throughout Wisconsin. The incidence of premature casting was higher in western and southern Wisconsin than northern and eastern parts of the state. This premature needle loss gave a dramatic appearance to affected white pine until the 1999 needles appeared. Both plantation-grown and natural stands were affected. No mortality was observed and the effect of premature needlecast is likely to be a slight decrease in growth for 1999. Two factors were associated with the casting: highway salt damage and infection by the fungus, *Mycosphaerella dearnessii*, the cause of brown spot needle blight. Both of these factors are common in Wisconsin on a small scale, yet widespread needlecast of white pine as observed in 1999 is not typical. Affected trees were located both close to salted highways and more than a ¼ mile away, eliminating salt damage as a singular causative agent. Premature needlecast in some locations could not be attributed to either of these factors. Similar symptoms were reported in the Lower Peninsula of Michigan and eastern Minnesota.

Jack pine budworm

Populations of **jack pine budworm** declined dramatically in Washburn, Douglas, and Bayfield counties but rose in Polk County where moderate defoliation occurred on 250 acres. Defoliation was light in Adams and Juneau counties although high egg counts here may cause defoliation again in 2000. The Appendix has tables of pupal, larval, parasite and predator counts in the Northwest region of Wisconsin.

Repeating spruce needle rust

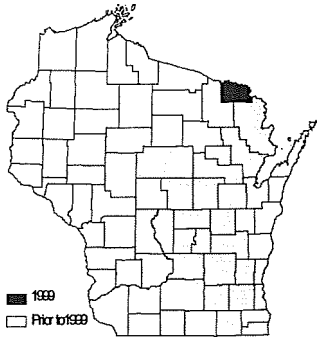


Severe **needle rust on spruce** was observed in a Christmas tree plantation in Lincoln County during the spring of 1999. Orange pustules were prominent on previous-year needles in May, and most of the infected needles fell off by early summer. From the timing of the symptom development, it is suspected that these trees are infected with a fungus, *Chrysomyxa weirii*. Although similar symptoms have been detected in the past, the extent of the damage due to this fungus in Wisconsin is not well known. Unlike other *Chrysomyxa* species that cause similar needle rust symptoms on spruce, *C. weirii* does not require an alternate host to repeat an infection. Thus, there is the potential that this fungus could cause significant damage on spruce in Christmas tree plantations.

Oak wilt

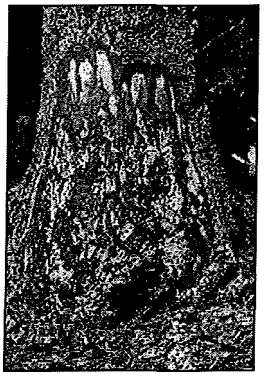
Oak wilt was reported for the first time in Florence County, at 3 separate residential sites in Spread Eagle (SWSE Sec.23 T40N R19E, SWSW Sec. 9 T39N R19E, NWSW Sec. 4 T39N R19E). A public hearing was held at the Florence Natural Resource Center to disseminate information about this disease. Oak wilt is now present in 52 of Wisconsin's 72 counties (see map below).

Efforts on oak wilt continue to concentrate on public information and surveys. Survey efforts are concentrated on the northern leading edge of this disease. A 5-year survey to determine the relationship between utility rights-of-way pruning and the overland spread of oak wilt was in its 4th year. This survey will be completed in 2000.

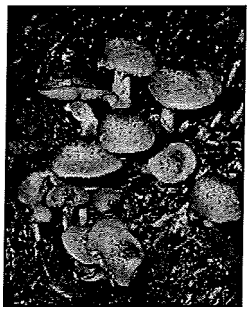


County distribution of oak wilt - 1999

Drought stress and Armillaria root rot on balsam-fir and spruce



The decline of balsam-fir and spruce became noticeable in northern Wisconsin during the spring of 1999. Most of the decline was seen on roadsides, in the understory, or close to water. Many trees turned completely brown and subsequent root excavation of several trees revealed infection by **Armillaria root rot**. Declining trees may have been predisposed by stress factors, such as salt, air pollution, or competition. Severe drought in 1998 and in the spring of 1999 may then have exacerbated the situation. Susceptible trees will often succumb to secondary infections, mainly by the parasitic fungi, *Armillaria spp.* Several trees that were not infected with Armillaria root rot started to grow new shoots this summer.



Armillaria often lives as a parasite on living host tissue or as saprophytes on dead woody material. The fungus most often identified as causing the disease is *Armillaria mellea* (Vahl: Fr.) Kummer. Recent research, however, indicates that several different but closely related species are involved. Therefore, the generic term *Armillaria* is used to refer to this group. These fungi are natural components of forests, where they live on the coarse roots and lower stems of conifers and broad-leaved trees.

As parasites, the fungi cause mortality, wood decay, and growth reduction. They infect and kill trees that have been already weakened by competition, other pests, or climatic factors. This type of activity occurs throughout the United States--especially in deciduous forests of the East. The fungi also infect healthy trees, either killing them outright or predisposing them to attacks by other fungi or insects.

Other Pests Reported in 1999

Pest	Host	Damage	Location
Ash			
Anthracnose *(Gnomoniella fraxini)*	Ash	Irregular dead tissues on leaves and moderate defoliation	Forest, Oneida counties
Ash plant bug *(Tropidosteptes amoenus)*	Ash	Leaf stippling common with scattered trees having substantial premature leaf drop	Washburn County
Mountain ash sawfly *(Pristiphora geniculata)*	European mountain ash	Defoliation common but less severe than normal	Washburn, Burnett, Sawyer counties
		Leaf browning and curling, premature leaf drop	Throughout West Central Region
Aspen			
Aspen blotch miner *(Phyllonorycter spp.)*	Aspen	Light defoliation present on roadside trees	Washburn, Burnett, Sawyer, Price, Rusk, Douglas, Bayfield counties
		Moderate mining damage	Lincoln, Oneida counties
Forest tent caterpillar *(Malacosoma disstria)*	Aspen	Scattered severe defoliation	Florence, Iron, Oneida, Vilas counties
Large aspen tortrix *(Choristoneura conflictana)*	Aspen	Populations down from last year. No visible defoliation.	Northwest Region
		Light to moderate defoliation	Florence, Oneida counties
Marssonina leaf spot *(Marssonina populi)*	Bigtooth aspen	Browning of leaves & premature leaf drop	Chippewa County
Venturia shoot blight *(Venturia tremulae)*	Aspen	Light to moderate infection. Dead shoots	Oneida County
Balsam fir			
Armillaria root rot *(Armillaria spp.)*	Balsam-fir	Tree mortality. Drought stress is a major probable inciting factor.	Throughout northeastern counties.
Balsam fir bark beetle *(Pityokteines sparsus)*	Balsam fir	Tree decline & mortality	Clark County
Rhizospaera needlecast *(Rhizosphaera pini)*	Balsam fir	Needle discoloration & loss	Clark County
Basswood			
Introduced basswood thrips *(Thrips calcaratus)*	Basswood	A light year for this pest	Northwest Region
		Pockets of light to severe defoliation	Florence, Forest, Langlade, Lincoln, Oneida counties
Birch			
Birch leafminer *(Fenusa pusilla)*	Paper birch	Light to moderate defoliation common on roadside	Washburn, Sawyer, Douglas, Bayfield counties
Butternut			
Butternut canker *(Sirococcus clavigignenti-juglanda cearum)*	Butternut	Cankers on trunks & branches. Some trees produced nuts.	Chippewa County

Pest	Host	Damage	Location

Cherry

Eastern tent caterpillar *(Malacosoma americanum)*	Cherry	Defoliation & webs in trees.	Scattered throughout West Central Region
		Light defoliation (down from previous year).	Polk, Burnett counties

Christmas Trees

Aphids *(Cinara spp)*	Scotch pine White pine White spruce	Discolored foliage	Chippewa, Adams counties
	Balsam fir Fraser fir	Discolored foliage	Dunn, Adams counties
Balsam Gall Midge *(Paradiplosis tumitex)*	Balsam fir	Swelling at base of needles	Dunn County
Balsam twig aphid *(Mindarus abietinus)*	Balsam fir	Moderate infestation	Eau Claire County
Fir needle rust *(Uridinopsis spp)*	Balsam fir Fraser fir	Browning of needles	Wood, Dunn counties
Lirula needlecast *(Lirula mirabilis, Lirula nervata)*	Balsam fir	Declined dramatically	Throughout Northwest Region
Pine root collar weevil *(Hylobius radicus)*	Scotch pine	Tree mortality	Buffalo County
		Substantial mortality anywhere Scotch pine grows	Throughout Northwest Region
Pine spittlebug *(Aphrophora cribrata)*	Scotch pine	Common but not at damaging levels	Throughout Northwest Region
Pitch midge on white pine *(Cecidomyia candidipes)*	White pine	Larvae have been found in pitch draining from wounds but caused no damage	Iowa and Winnebago counties
Spruce needle rust *(Chrysomyxa spp.* probably *C. weirii)*	Spruce	Heavy infection. Needles with white pustules were dropped by summer. Yellow bands on current-year needles.	Lincoln County
Spider mites *(Oligonychus ununguis)*	White spruce	Needle loss	Wood County
Fir needle rust *(Uridinopsis spp.)*	Balsam fir Fraser fir	Discolored foliage	Dunn, Adams County
White pine weevil *(Pissodes strobi)*	White pine White spruce	Leader mortality	Eau Claire, Marathon, Chippewa counties
		Light year	Northwest Region

Crab Apple

Apple scab *(Venturia inaequalis)*	Crab apple	Moderate infection on leaves and fruit.	Lincoln, Oneida counties
Red-humped caterpillar *(Schizura concinna)*	Crab apple	Light to moderate defoliation	Lincoln County

Elm

Dutch elm disease *(Ophiostoma ulmi)*	American elm	High mortality in few remaining trees (5-6 elms died in 1999)	Washburn, Sawyer counties

Pest	Host	Damage	Location

Hemlock

Armillaria root rot *(Armillaria* spp.*)*	Eastern hemlock	Tree mortality. Often observed with hemlock borer damage.	Forest, Oneida, Vilas counties
Hemlock borer *(Melanopila fulvoguttata)*	Eastern hemlock	Heavy infestation on individual trees. Tree mortality. Often observed with Armillaria root rot.	Forest, Oneida, Vilas counties

Larch

Larch needlecast *(Mycosphaerella laricina)*	European larch	~40% defoliation occurred on 40% of trees in 10 acre plantation	Lorain Township, Polk County

Maple

Bruce spanworm *(Operophtera bruceata)*	Sugar maple	Moderate to complete defoliation	Florence, Forest, Langlade, Menominee counties
Greenstriped mapleworm *(Dryocampa rubicunda)*	Red maple	Heavy defoliation of red maple	Chippewa, Washburn counties
		Numbers down in northwest but still ~200 acres of defoliation.	Frog Creek Township, Washburn County
Maple leafroller *(spp)*	Sugar maple	Light to moderate infestation	Forest, Oneida counties
Maple petiole borer *(Caulocampus acericaulis)*	Sugar maple	Light defoliation only	Washburn, Sawyer, Price counties
		Light infestation	Lincoln County
Maple webworm *(Tetralopha asperatella)*	Sugar maple	Light to moderate webbing	Vilas County

Miscellaneous hardwoods

Fall webworm *(Hyphantria cunia)*	Hardwoods	Defoliation and webs in trees	Scattered throughout West Central Region
		Light to moderate webbing and defoliation.	Lincoln, Oneida counties
		Moderate defoliation common on tag alder	Sawyer, Price counties
Lecanium scale *(Parthenolecanium* spp.*)*	Hardwoods	Many shells attached on twigs. Twig dieback.	Florence, Forest, Vilas counties

Oak

Anthracnose	Oak	Browning & curling of leaves	Clark County
Forest tent caterpillar *(Malacosoma disstraia)*	Red oak	Scattered light to moderate defoliation	Oneida County
Kermes scale *(Kermes spp.)*	N. pin oak	Common twig & branch dieback	Washburn, Burnett, Douglas counties
Oak apple gall (Synipid wasps)	Red oak	Light to moderate infestation. Gall found on leaves, buds, and acorn cups.	Oneida, Price counties
Oak lace bug *(Coryathuca arcuata)*	Bur oak	Very light bronzing only	Washburn, Douglas counties
Oak leaf tier *(Croecia semipurpurana)*	Red oak	L-M defoliation prevalent	Washburn, Burnett, Sawyer counties
Oak leaf roller	Red oak White oak	Leaves rolled together & associated feeding damage.	Clark County

Pest	Host	Damage	Location
Oak spider mites *(Oligonychus bicolor)*	Red oak	Light to heavy leaf bronzing and necrosis. Light defoliation.	Lincoln, Oneida, Vilas counties
Oak tatters	Red oak	Deformed leaves	Clark County
Oak twig girdler *(Oncideres cingulata)*	N. pin oak	Present but most of twig dieback was caused by Kermes	Northwest Region
Oak webworm *(Archips fervidana)*	N. pin oak	Leaves skeletonized & webbed together.	Clark County
		Populations way down, webs rare in sand country.	Northwest Region
Oak wilt *(Ceratocystis fagacearum)*	Red oak Black oak	Tree mortality	Scattered throughout West Central Region
		New pockets, first report of infestation in Florence Co.	Florence County
	N. pin oak	Minor growth of existing pockets but no major movement	Anderson Township, Burnett County
Orangestriped oakworm *(Anisota senatoria)*	Oak saplings	No defoliation	Northwest Region
Phylosticta leaf spot *(Phyllosticta minima)*	Red Oak	Several spots on infected leaves	Oneida County
Pinkstriped oakworm *(Anisota virginiensis)*	N. pin oak	No defoliation	Northwest Region
Spring frost damage	N. pin oak	Oak was badly damaged on Trego & Springbrook frost flats	Washburn County
Two-lined chestnut borer *(Agrilus bilineatus)*	N. pin oak	Endemic levels	Northwest Region
Walkingstick *(Diapheromera femorata)*	N. pin oak	Found a few but no defoliation	Northwest Region

Pine

Armillaria root rot *(Armillaria mellea)*	Red pine White pine	General decline of trees	Jackson County
		Light scattered mortality (<5%) in plantations	Washburn, Burnett, Douglas, Bayfield, Sawyer counties
Dook's needle blight *(Lophodermium spp.)*	White pine	Disappeared in 1999	Northwest Region
Ips bark beetles (*Ips* spp.)	Jack pine Red pine	Tree mortality scattered throughout WCR Heavy attack in storm damaged pines ('98)	Monroe County.
		Endemic population in early 1999 but we have thousands of acres of pine blowdown	Douglas, Bayfield counties
Ips bark beetles *(Ips spp)*	Red pine	Pockets of tree mortality	Lincoln County
Jack pine budworm *(Choristoneura pinus)*	Jack pine	Light defoliation although high egg counts may cause defoliation in 2000.	Adams, Juneau counties
		Defoliation & high numbers of early larvae in early summer. Population collapsed, no egg masses.	Monroe County
		Population crashed everywhere except ~ 200 acres L-M defoliation in Sterling	Polk County

Pest	Host	Damage	Location
Mound ants *(Formica exsectoides)*	Jack pine	Trees declining where mounds are shaded	Wood County
Pine needle midge *(Contarina baeri)*	Red pine	Light – very light defoliation except for 2 small pockets of heavy defoliation	Washburn County (500 acres) Burnett Country (150 acres)
Pine root tip weevil *(Hylobius rhizophaqus)*	Jack pine Red pine	Continued dieback in mixed jack & red pine plantings.	Washburn, Burnett, Douglas counties
		Branch flagging & general decline	Jackson County
Pine tortoise scale (*Toumeyella parvicornis*)	Jack pine	Tree decline & heavy sooty mold	Wood County
Red pine decline	Red pine	Pocket of ~50 trees continues to senesce in DeBrock plantations. No additional mortality since 1998	Wascott Township, Douglas County
Red pine pocket decline	Red pine	Tree decline & mortality	Clark County & scattered locations throughout WCR
Red pine shoot moth *(Dioryctria resinossella)*	Red pine	Populations crashed since 1998: almost no flagged shoots	Northwest Region
Salt & drought damage	Red pine White pine	Needle chlorosis, burning & loss	Scattered throughout West Central Region
Sphaeropsis collar rot and shoot blight (*Sphaeropsis sapinea)*	Jack pine Red pine	Tree, shoot & branch mortality. Thinning crowns (tufted foliage) general tree decline.	Clark, Eau Claire, Jackson counties
		Scattered cankers present in pockets in red & jack pine plantations	Douglas County
White pine blister rust *(Cronartium ribicola)*	White pine	Normal year as scattered trees continue to succumb.	Northwest Region

Spruce

Armillaria root rot *(Armillaria* spp.*)*	Spruce	Tree mortality. Drought stress is a major probable inciting factor.	Throughout northeastern counties.
Chlorosis of needles	White spruce	Tree decline leading to mortality	Taylor County
Cytospora canker (*Leucostoma kunzei*)	Spruce	Light dieback in lower branches of blue spruce	Across northwest Region
Rhizosphaera needlecast (*Rhizosphaera kalkhoffii*)	Spruce	Light defoliation only of blue spruce	Washburn, Sawyer counties
Spruce budworm *(Choristoneura fumiferana)*	White spruce	Defoliation – light to moderate	Marathon County
		Close to extinct, way down from 1998	Northwest Region
Yellow-headed sawfly *(Pikonema alaskensis)*	White spruce	Down year for this perennial problem	Northwest Region

Tamarack

Larch casebearer (*Coleophora laricella*)	Tamarack	Present but not really noticeable	Northwest Region
		Moderate to severe infestation. Severely damaged trees reflushed in June.	Oneida County

Special Investigations and Surveys

Jack Pine Budworm Survey Procedures & Results: 1999

(Shane Weber, DNR Forest Entomologist, Spooner, WI)

Jack pine budworm early larval survey

This survey is done on a yearly basis and is a key indication of the presence of destructive budworm populations. Thirty shoots and staminate flowers (15 of each) that can be reached from the ground are checked for larvae. Since staminate flowers are often scarce some years, a majority of shoots are usually used. A count of 20 or more infested shoots and flowers is considered sufficient enough to cause moderate to severe defoliation.

Early Larval Populations

County	# Plots	# Infested Shoots	# Infested Shoots / Plot	# High Plots	% High Plots
Polk	15	39	2.60	2	13.3
Burnett	24	31	1.29	1	4.2
Washburn	21	138	6.57	6	28.6
Douglas	54	225	4.17	5	9.3
Bayfield	32	52	1.63	0	0
Region	**146**	**485**	**3.32**	**14**	**9.6**

Early Larval Population Trends

	# Infested Shoots per Plot				% of High Plots		
County	1997	1998	1999	% Change 1998-1999	1997	1998	1999
Polk	0.93	0.67	2.60	+288	0	0	13.3
Burnett	0.78	1.46	1.29	-12	0	4.2	4.2
Washburn	1.90	7.14	6.57	-8	5.0	28.6	28.6
Douglas	10.84	13.03	4.17	-68	60.8	81.5	9.3
Bayfield	13.43	7.47	1.63	-78	67.9	25.0	0
Region	**7.29**	**7.79**	**3.32**	**-57**	**37.2**	**40.4**	**9.6**

Jack Pine Budworm Pupal Survey

Again, this survey is conducted on a yearly basis and gives a good indication of the kinds and numbers of pupal parasites in the population as well as next year's population of jack pine budworm. It is done in July when most insects are in the pupal stage. Some adults may already have emerged, but empty pupae cases are collected and counted as emerged moths. At each stop, pupae are collected on a time basis. If five pupae are not found in five minutes, the collection is terminated. If five pupae are found in five minutes or less, the collection is continued until 25 pupae are found or until 15 minutes have elapsed. The time it took to find 25 pupae is then recorded. Later, adults, parasites, and non-emergence is recorded for each pupae.

Pupal Survey

County	Total Pupae	Total Minutes	Pupae/ minute	Moths		Parasites		Non-emerged	
				No.	%	No.	%	No.	%
Polk	60	95	0.63	37	61.7	17	28.3	6	10.0
Burnett	65	147	0.44	44	67.7	18	27.7	3	4.6
Washburn	103	155	0.66	57	55.3	37	35.9	9	8.8
Douglas	34	270	0.13	24	70.6	10	29.4	0	0
Bayfield	4	160	0.03	3	75.0	1	25.0	0	0
Region	**266**	827	0.32	165	62.0	83	31.2	18	6.8

Pupal Population Trends

County	1997 upae/minute	1998 upae/minute	1999 upae/minute	% Change 1998-1999
Polk	0.03	0.37	0.63	+70
Burnett	0.06	0.39	0.44	+13
Washburn	0.62	1.45	0.66	-54
Douglas	1.60	1.30	0.13	-90
Bayfield	1.37	0.98	0.03	-97
Region	**1.10**	**1.08**	**0.32**	**-70**

Jack Pine Budworm Parasite and Predator Survey

This survey involves a careful examination of all the budworm pupae collected which do not produce moths. Adult specimens are compared to a reference collection. Any unknown adults are sent to the University of Wisconsin for identification. Pupal casses from which nothing emerges are dissected to ascertain the cause of failure.

Parasite & Predator Complex			
	Total	**Percent of Parasitized**	**Percent of Total**
Itoplectes	16	19.3	6.0
Scambus	3	3.6	1.1
Phaogenes	22	26.5	8.3
Agrypon	1	1.2	0.4
Pteromalids	8	9.6	3.0
Tachinids	15	18.1	5.6
Predators	18	21.7	6.8

Parasite & Predator Complex										
	Polk		**Burnett**		**Washburn**		**Douglas**		**Bayfield**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Itoplectes	8	47.1	4	22.2	4	10.8	0	0	0	0
Scambus	1	5.9	0	0	2	5.4	0	0	0	0
Phaogenes	1	5.9	1	5.6	13	35.1	6	60.0	1	100
Agrypon	0	0	0	0	0	0	1	10.0	0	0
Pteromalids	1	5.9	3	16.7	3	8.1	1	10.0	0	0
Tachinids	3	17.6	4	22.2	8	21.6	0	0	0	0
Predators	3	17.6	6	33.3	7	18.9	2	20.0	0	0
Total	**17**	**100**	**18**		**37**	**100**	**10**	**100**	**1**	**100**

Insects and Pathogens Affecting Forest Health of Red Pine

UW PRINCIPAL INVESTIGATOR: Kenneth F. Raffa, Professor, Department of Entomology, University of Wisconsin - Madison

DNR PROJECT LIAISON: Jane Cummings - Carlson

PERIOD: April 1, 1997 - May 30, 2000

BUDGET: $25,000 / yr.

BACKGROUND:

Red pine plantations in Wisconsin are currently experiencing significant decline. The cause or causes of these losses are not understood. Most likely, there is no single causal agent. Instead, a variety of insects, fungi, and site factors interact, and the relative importance of these various factors varies among sites. However, the symptoms at the stand level exhibit a rather common pattern. Affected trees are often arranged in concentric patterns. Center-most trees are dead, and adjacent trees show crown thinning. Each year, these regions increase in radius. Thin - crowned trees die, and previously healthy trees show crown symptoms. These symptoms most commonly occur in stands that are pre-merchantable.

OBJECTIVES:

The purpose of this research is to identify insects and pathogens associated with declining red pine stands, identify abiotic factors that favor their abundance and virulence, and develop monitoring methods for predicting the occurrence of potentially damaging species.

METHODS:

We established 17 plots throughout central and western Wisconsin. These plots included 9 declining sites, 4 control sites, and 4 control sites adjacent to declining sites. We conducted surveys of insect abundance, disease symptoms, and site factors.

Insects were surveyed using three types of traps: Baited (racemic ipsdienol & lanierone) multiple funnel pheromone traps (Wood 1982, Lindgren 1983, Raffa 1991), baited (+alpha pinene & ethanol) jug traps (Rieske & Raffa 1993), and baited (-alpha pinene & ethanol) pitfall traps (Hunt & Raffa. 1989). The first type of trap is aimed primarily at sampling bark beetles, wood borers, and predators. The second type of trap is designed to capture turpentine beetles and stem weevils. The third type is intended to capture root insects. Insects were sampled every 15 days during the 1997, 1998, and 1999 insect flight seasons.

Disease symptoms and pathogens were sampled using three methods. The first consisted of a systematic sampling of roots. At each of the 17 sites, 8 trees were sampled. Four were at the edge of the pocket margin, and 4 were in asymptomatic regions of the stand. Root tissue was collected from each tree, and isolations are being conducted. The main targets of this approach are Leptographium and Armillaria. The second method consisted of using red pine stem sections to sample Heterobasidion annosum. Five stem sections were deployed at each site, and at a site known to contain this pathogen. The third method consisted of excavation of plots, to allow for detailed examination of root tissue, adjacent to and distant from the root collar. This method is intended to allow for an opportunity to examine other possible causal agents.

Abiotic analyses include three methods. The first consists of mapping each site and collecting radial increment cores. We are examining possible correlations among pocket size, tree growth rates, tree

relative growth rates, and mortality. The second method consists of collecting soil samples. These are being analyzed by the University of Wisconsin Soil and Plant Analysis Laboratory (Schulte et al. 1987.) for N, K, P, pH, soil texture, and % organic matter. The third approach consists of analyzing archival NOAA climatological data for possible relationships between weather and declining red pine stands. Some of the factors under consideration include minimum daily temperatures (with the possibility that high minimums could allow excessive evapotranspiration), and extremes in precipitation (which could lead to either drought or root flooding).

RESULTS:

We have completed three years of insect sampling. All of the insects from 1997, 1998, and 1999 are identified, tabulated, and entered into computer data bases. The major stem colonizing insects were Ips pini (85359), Ips grandicollis (20177), and Monochamus carolensis (80). Thus, I. pini appears to be the most important insect in this group. The most abundant predators were Thanasimus dubius (6739), Platysoma cylindrica (1773), Platysoma parallelum (648), and Enoclerus nigripes (322). The major insects captured in jug traps were Ambrosia beetles (1879), Pissodes nemorensis (629), Orthotomicus caelatus (328), and Dendroctonus valens (195). The major insects captured in pitfall traps were Hylastes porculus (1895), Hylobius pales (1321), Hylobius radicis (472) and Hylobius rhizophagous (155).

The major difference between declining and control stands, was that the former sites had fewer predators of bark beetles. Moreover, nondamaged portions of declining sites had predator populations more similar to the pockets than to the true controls, indicating there is something inherently different about sites that do or do not contain pockets.

Root sampling was completed during August, 1998 and 1999. Direct examination of roots indicated black-staining in association with root insects, but little else. Isolations from these specimens is underway. Red pine disks were deployed in November, 1998. Heterobasidion was isolated from the "positive control" plot near Coon Rock Rd. in Iowa Co. However, it was not isolated from any of the other stands. Three stands were excavated. Direct examination of the exposed roots did not reveal any signs or symptoms of disease that were different from observations made during the intensive sampling.

Soil samples were collected in July, 1998. These have been processed, and the data are currently being analyzed.. Analysis of climatological data is underway.

CONCLUSIONS:

The populations of predators of bark beetles may be important in reducing pest numbers, and hence in maintaining healthy red pine stands. Site specific features appear important in supporting predator populations. Future work should emphasize identifying an fostering these site characters.

The major pathogens present appear to be Leptographium, in association with root insects. This agrees with previous observations by Raffa & Hall (1988), and Klepzig et al. (1991). There is no evidence of widespread incidence of Heterobasidion. However, methods development needs further evaluation.

ACKNOWLEDGMENTS:

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GRADUATE TRAINING THROUGH ON FUNDED RESEARCH:

This work supported the training of a doctoral student, N. Erbilgin.

PUBLICATIONS BASED ON FUNDED RESEARCH:

Erbilgin, N, & K.F. Raffa. Effects of host tree species on attractiveness of tunneling pine engravers, *Ips pini* (Coleoptera: Scolytidae), to conspecifics and insect predators. J. Chem. Ecol. In press.

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PRESENTATIONS BASED ON FUNDED RESEARCH:

North Central Forest Pest Workshop. Sept.1998. Effects of host tree species and chemistry on the response of *Ips pini* and its major predators to I. pini pheromones". N. Erbilgin & K. F. Raffa

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Integrated Pest Management of Gypsy Moth in Eastern Wisconsin, 1999

Andrea Diss, Gypsy Moth Coordinator
Dept. of Natural Resources, Madison, WI

Integrated Pest Management (IPM) of gypsy moth in the areas where it is established includes a variety of efforts. Suppression of outbreaks is the most recognized management tool but it is not the only one that must be implemented in order to manage this insect successfully. The Wisconsin IPM program includes suppression, biological control introductions, silviculture, and a vigorous education program. Together, these efforts will reduce the impact of gypsy moth outbreaks on people and forests, both rural and urban, of Wisconsin.

Suppression

Suppression of outbreaks is the reduction of a population that is high enough to cause significant damage to a lower level where it is no longer a problem. The population of the pest is reduced but not eliminated in the area treated in the year of treatment. Suppression treatments involve the use of pesticides applied either from the ground, for smaller areas, or aerially when the area treated exceeds several acres.

The DNR is proposing to offer two options for participation in suppression of gypsy moth outbreaks, a federal program and guidance on running privately funded treatments. The USDA Forest Service offers cost sharing for suppression, up to 50% of the expenses of preparing and executing a treatment. The criteria for participation in this program are:

Minimum Acreage: 40 contiguous acres

Minimum Canopy Coverage:
- Residential (≥1 residence/5 acres): 25%
- Rural (<1 residence/5 acres): 50%

Minimum % Preferred Host: 50%
- Preferred hosts include oaks, basswood, crabapples, birch, aspen, willow and others.

Egg Masses/Acre:
- Residential (≥1 residence/5 acres) and high use recreational: 500
- Rural (< 1 residence/5 acre) and low use recreational : 1000

The federally sponsored cost sharing program will involve the participation of counties. Their role is being negotiated. The DNR has also requested hiring coordinators who would administer this program in the 01-03 budget request. These coordinators would allow participation in the federal program for treatments planned for spring of 2002. In order to be able to provide this cost sharing program for treatments in spring 2001, these coordinators would need to be hired in the summer of 2000.

The DNR is also offering guidance for landowners who wish to organize their own privately funded spray program. I am currently adapting a packet developed by Minnesota on how to run a treatment program which includes how to organize your community, get permission from all participants, collect money and bid out the treatment. I have used this packet in the past with a community in Marinette to reduce an outbreak of forest tent caterpillar and it worked well. The community was very pleased with the results and local control the privately run program provided. They were also able to successfully compete for a

good price for the treatment. In fact, their cost of $15/acre was half the cost of the state treatment program for gypsy moth eradication at that time. I expect to have the final version of this information packet available to the public at the end of March.

Education

Because both suppression options are responsive to landowner requests, it is imperative that landowners be able to assess the seriousness of gypsy moth populations and be aware of the management options available to them. To this end, the DNR and other members of the Cooperative Gypsy Moth Program have developed an education program focused on survey techniques and the variety of management options appropriate for different situations. This education program started in the fall of 1999 with a series of intensive workshops for city foresters, arborists (both private and public), and parks and property managers. We approached this group first as gypsy moth outbreaks appear to be developing initially in parks and because the public and politicians often turn to these people first for advice and action. The second series is an education program for educators such as extension personnel, master gardeners, naturalists, and members of garden and nature clubs. Once this group is trained, we will be using these local experts to help meet the need for information by the general public on gypsy moth and it's management. This "Train the Trainers" series will be presented in towns from Wausaukee to Kenosha in March, 2000 including two sessions in Fond Du Lac on March 2nd. We are now starting the third series which addresses the information needs of communities with high populations of gypsy moth. While areas with gypsy moth populations high enough to cause noticeable damage are still relatively small and scattered, there are neighborhoods where treatment is planned or could be considered for this spring. In these communities, we are providing a program to train residents on how to determine if they have a problem level of gypsy moth, and then what they can do to prevent damage. Management techniques demonstrated or described include finding and removing egg masses, barrier and collection bands, insecticide injection, insecticide spraying from the ground and organizing an aerial spray. The first of these "Train the Neighborhood" sessions will be held in February 2000 in Brookfield. This session will provide an opportunity for residents to meet and start the organization necessary to do a spray program. City foresters in Milwaukee and Appleton are planning more such training sessions in these cities where they will be treating trees in some of the parks this spring and DNR pest specialists will be participating as presenters. In the fall of 2000, these informational series will be repeated as necessary and will be adding information on the federal suppression program when it is available. Similar presentations will be given to interest groups such as the Wisconsin Woodland Owners and Arborists Societies.

A variety of publications are available by request to the front desk of any DNR Service Center. You may order as many as you like at no cost except for the color poster for which there is a limit of 50 free copies. If you would like a large number of posters for a special event, please call Andrea Diss at 608-264-9247.

What to Do About Gypsy Moths in Your Backyard FR 157-00 Available 3/1/00

- Good for the homeowner, no photos. Covers egg mass removal, barrier bands, collecting caterpillars under burlap bands and a brief discussion of pesticides.

Guides to predicting Gypsy Moth Damage FR 156-00 Available 3/1/00

- Most useful for woodlot owner. How to conduct a predictive survey for gypsy moth outbreaks.

Gypsy Moth Poster FR 131-98

- Color poster with photos of all life stages on front, a good introduction to the pest's biology, impact and management on the back.

Gypsy Moth Silvicultural Guidelines for Wisconsin FR 123-97
- Appropriate for those with forestry background.

Forest Management Strategies to Minimize the Impact of the Gypsy Moth
Forestry Facts No. 83
- Appropriate for most landowners.

A curriculum for high school students including several projects has been developed in cooperation with Vocational Agriculture teachers. This curriculum is available on the DNR website. In the spring of 2000, the slide show that is part of the curriculum and which covers identification, biology, impacts and management will also be available on the website as a Powerpoint presentation that can be downloaded. There will also be a clip art library at the site with black and white illustrations that can be used in publications.

Biological Control

While natural enemies can't prevent or suppress outbreaks, they can slow population growth of the pest and make outbreaks less frequent. Since gypsy moth is not native to North America, it has been necessary to introduce the natural enemies that specifically attack this pest. In Wisconsin, we have selected three species that are specific to the gypsy moth: the fungal disease,*Entomophaga maimaiga*, the egg parasite, *Ooencyrtus kuvanae*, and the larval parasite *Cotesia melanoscela*. The fungal disease has had significant impacts on gypsy moth populations in eastern states and Michigan, particularly in years with wet springs. We have successfully established this disease at 23 sites in eastern Wisconsin. *Ooencyrtus* can attack up to 40% of the eggs in a gypsy moth egg mass and is considered one of the best natural enemies of the pest. This tiny wasp is well established in Milwaukee and Waukesha counties and we have found it at lower densities throughout the shoreline counties north to Oconto. Due to limited numbers of *Cotesia* available from the USDA rearing facility, we have only been able to release this miniature wasp into five sites, three in the Green Bay area, one in Milwaukee and one in Waukesha.

In the fall of 2000 and in the future, I will continue to make releases of*Entomophaga* and *Cotesia*. I am planning an exchange of *Ooencyrtus* infested egg masses from towns which have an abundance to those where the wasp is not yet established working with city and town foresters. I will continue to work with federal agencies to obtain specific and appropriate natural enemies as they become available.

Silviculture

We have developed two publications on silviculture to minimize damage from gypsy moth outbreaks. These are available through DNR service centers. We will also be presenting a demonstration thinning of a woodlot to reduce future impacts of the gypsy moth in the Southern Kettle Moraine State Forest in the fall of 2000 for woodlot managers.

Forest Health Monitoring
(Background and 1999 Activity)

Teague Prichard, Wisconsin DNR, Air Management, Madison, WI

The Forest Health Monitoring (FHM) program is designed to determine the status, changes, and trends in indicators of forest condition on an annual basis. This program uses data from ground plots and surveys, aerial surveys, and other biotic and abiotic data sources and develops analytical approaches to address forest health issues that affect the sustainability of forest ecosystems.

The FHM program developed from growing environmental concerns about air pollution, acid rain, global climate change, population growth and long-term resource management on our forest resources. In response to these concerns federal and state agencies have fostered a cooperative effort to develop and implement a comprehensive program for monitoring the status and trends of forest ecosystem health.

The FHM program is comprised of three inter-related monitoring activities:

- **Detection Monitoring**
- **Evaluation Monitoring and**
- **Intensive Site Ecosystem Monitoring**

Detection Monitoring is the most extensive of FHM's three monitoring activities. It is designed to provide data to determine base line or current conditions of forest ecosystems, and detect changes and trends over time. This information is analyzed to determine if detected changes are anticipated, and if those changes indicate improving forest health or are cause for concern, warranting additional evaluation. Detection monitoring covers all forested lands and has two components. Together these components describe forest health;

(1) ***the plot component***, which are measurements made on the FHM network of permanent plots; and
(2) ***the survey component***, which is forest surveys of insects, disease and other effects causing stress, conducted independently of the FHM plot component.

The Plot Component

The basis for the FHM plot component is a network of permanent plots distributed on a systematic grid across the entire U.S. Measurements or groups of measurements called indicators are collected yearly on the plots. An indicator is defined as any biological and non-biological component of the environment that quantitatively estimates the condition or change in condition of ecological resources, the magnitude of stress, or the exposure of a biological component to stress. The current set of indicators being measured in the plot component of detection monitoring include: mensuration, crown condition, damage assessment, ozone bioindicator plants, vegetation diversity, lichens, and soils.

The Survey Component

The symptoms of natural and human-caused stressors that affect forests are detected and measured with aerial and ground surveys. Important stressors are insects, diseases, climate changes, extreme weather, and air pollution. Commonly measured symptoms include defoliation, foliage discoloration, tree dieback, branch breakage, main stem breakage, uprooted trees, and tree mortality.

FHM Plot Design

Each FHM plot has four fixed-area, circular subplots (Figure 1). Subplot centers are spaced 120 feet (36.6m) apart. All subplots are 1/24-acre (1/60 hectare) in size and contain a micro-plot offset 12 feet (3.7m) from the subplot center. The micro-plots are 1/300-acre (1/750-hectare) in size.

Most tree measurements are taken within the subplots. Seedlings and saplings are measured on the micro-plots. Annual plots are used for the tree measurements that require collecting a physical sample. This allows the subplots to remain unaltered by sample collection.

FHM Sampling Design

The FHM sampling design is a spatially and temporally systematic sample on a national hexagonal base grid located 27 km apart. The sampling design minimizes the number and frequency of plot visits without reducing precision to an unacceptable level.

Rotating panel and interpenetrating design are related and non-interchangeable terms describing the FHM design. Rotating panel means that a specific group of plots (a panel) is measured at a specified frequency (for example, every four years). Interpenetrating design describes how the plots are grouped into panels – the FHM plots in any panel are chosen so they are uniformly distributed within the monitoring area. Each level – the base grid, the panel, and the overlap – is an equal area sample of the same geographic area. This means that for a given level, each plot represents the same number of acres. All plots are equidistant from all adjacent plots.

Forested plots on the base grid are measured on a four-year cycle with 1/4 of the plots (called a panel) measured every year. In addition, 1/3 of the plots from the previous years panel (called the overlap) are measured. This overlap is 1/12 of the base grid. When the design is implemented for the first time, all plots are established and measured the first year. This complete measurement provides an estimate of initial status and improves precision in estimating change in forest health within two years after the entire base grid is established.

The design can be easily modified to meet more stringent or less stringent data requirements as program objectives evolve. For example, the sample size can be increased either permanently or temporarily in geographic areas that have high levels of biological or anthropogenic (human-caused) stress. In states where policy decisions require greater precision than that provided by the national grid, the sampling intensity can be increased in that state without losing compatibility with other states.

Forest Health Indicators - Definitions and Regional Results

Crown Ratings

Crown evaluations indicate tree condition by indirectly assessing an individual tree's ability to capture light and produce carbohydrates by photosynthesis. Six measurements are made for the trees crowns; crown diameter, live crown ration, crown density, crown dieback, crown transparency and crown vigor. These measurements, except for crown vigor, are made on all live trees 5.0 inches diameter at breast height and larger. The measurements for live crown ration, crown density, crown dieback and crown transparency are assigned range from 0 to 100 percent, by 5 percent classes. FHM field crews collect crown data during the normal field season that begins in early June and ends in early September.

Crown Diameter requires two measurements, one at the widest point and a second diameter measurement made 90 degrees to the diameter at the widest point. If viewed from the air, the crown diameter is the average of an oval including all foliage.

Live Crown Ration is the percentage of height which supports live, green foliage that is contributing to total height growth.

Crown Density is a measure of how complete an individual tree crown is when compared to a full-crown outline. Crown density represents the amount of foliage, reproductive structures (seeds and cones), and branches that obstruct skylight visibility through the crown. Trees with high scores for crown density generally have high potential for survival and reproduction.

Crown density values greater than 20% indicate more active crown areas and healthier trees, values less than 20% indicate poor crown condition.

Crown Dieback is the percentage of recent branch mortality that begins at the terminal portion of branches and proceeds toward the trunk, excluding portions caused by natural shading or competition. Dieback is caused by severe shock to root systems, drought or disease. Some species show natural light dieback as part of normal growth.

Foliage Transparency is an indicator of light filtering through needles and leaves in the upper one-third of the crown. Transparency values differ by species and depend on natural branching habit and foliage orientation. High transparency values (>50%) indicate unhealthy crown conditions. Reduce foliage can be caused by insects disease and other stressors.

Damage

Pathogens, insects, air pollution, and other natural or human disturbances all cause damage and can adversely affect the health of the tree and ultimately the forest. The FHM program collects data on up to three instances of damage per tree, limiting observations to certain types of damage, which may potentially kill or adversely affect the trees long-term survival. For each tree the location and an assessment of the degree of severity are also recorded. Types of damage include; cankers, conks, open wounds, resinosis, dead tops / loss of apical dominance, broken limbs, branches and roots, brooms, damaged foliage, and discolored foliage.

Air Pollution

The effects of air pollution on forest ecosystems are evaluated regionally in the FHM program in three ways: ozone bioindicator plant evaluation; lichen community analysis focusing on sulfur and nitrogen sensitive species; and soil chemistry analysis evaluating soil pH and exchangeable Ca, Mg, and K.

Ozone Bioindicator Monitoring

Ozone bioindicator plants are vascular plant species (herbs, shrubs, or trees) that are highly sensitive to ozone air pollution and respond with distinct foliar injury symptoms that can be diagnosed under field conditions. Ozone bioindicator plants are evaluated on or near the FHM plots in suitable openings (>0.5 acre) where the appropriate ozone-sensitive plant species are found. Plots are scored as positive or negative for ozone injury. The severity of ozone injury at each plot is also recorded.

Lichen Monitoring

Lichens are fungi that live in intimate association with algae. Lichens are very responsive to environmental stressors in forests, including changes in forest structure, air quality, and climate. In FHM, data is collected on epiphytic lichens, those growing on trees and shrubs. Because the effects of air pollutants on trees can be difficult to separate from other influences on growth, epiphytic lichens provide a clear indication of potential air quality impacts on total forest productivity.

Lichen community measurements are made within a 120-foot-radius circle centered on each FHM field plot. Additional data can be collected from urban and industrial sites to help define lichen community response to air pollution in each region. FHM crews are trained to collect a sample of each species found and record the relative abundance of each species. Lichen experts do the actual species identification.

Soil Chemistry

Soil morphology (physical characteristics) and chemistry indicators of ecological condition are used in FHM to evaluate the below-ground portion of forest ecosystems. Measurements will be made of A, E, B, or C mineral horizons as deep as 40 inches from the soil surface, including any overlying O horizon (organic horizon) and forest floor deposits.

Conclusions and Future Direction for FHM program in Wisconsin

In the beginning of this report, forest health monitoring was defined as a long-term program to determine base line or current conditions of forest ecosystems, and detect changes and trends over time. The plot and survey component of the program have proved useful in establishing baseline data for forest health. We now have six years of forest health monitoring plot data. Although the FHM program can not draw conclusive conclusions for Wisconsin alone, forest health monitoring data indicates that the Lake States forests, including Wisconsin are generally in good health.

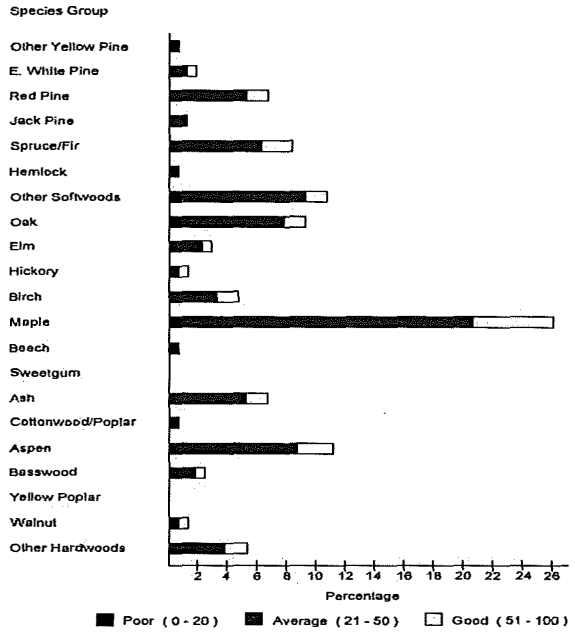


Table 1. Crown density by species group in the North Central region, FHM 1998.

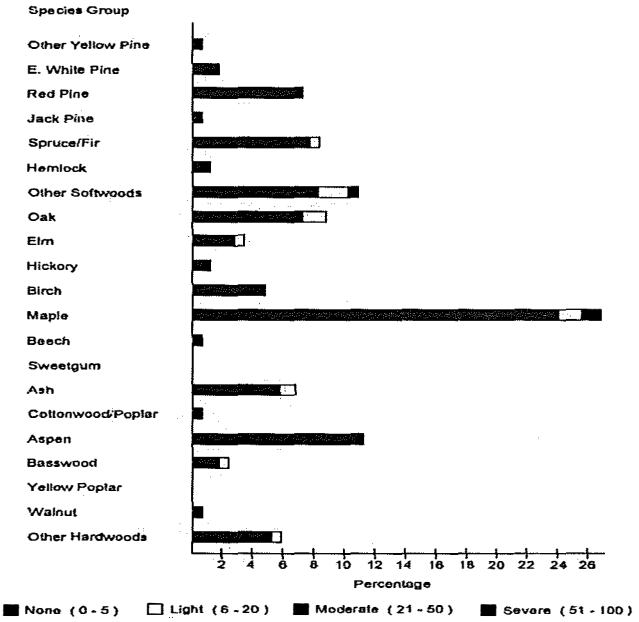


Table 2. Crown dieback by species group in the North Central region, FHM 1998.

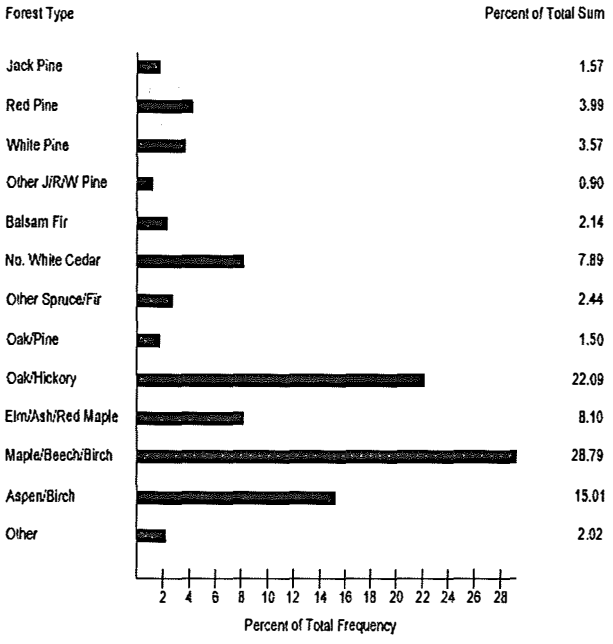


Table 3. Forest types on the North Central region plots, FHM 1998.

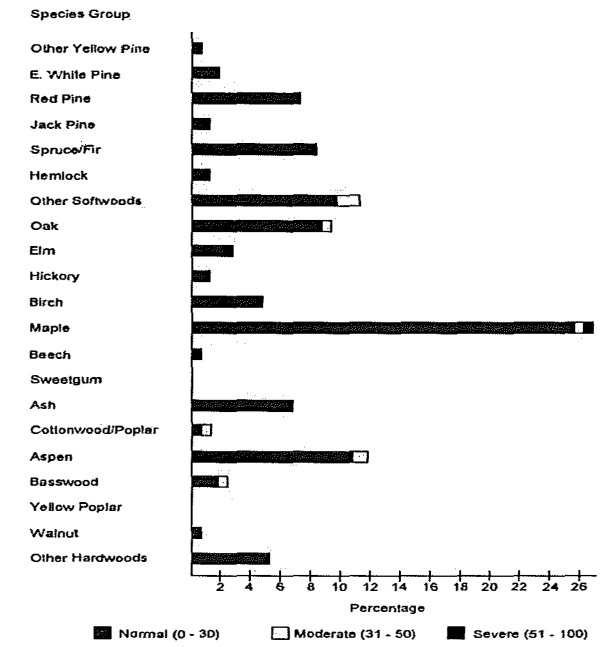


Table 4. Foliage transparency by species group in the North Central region, FHM 1998.

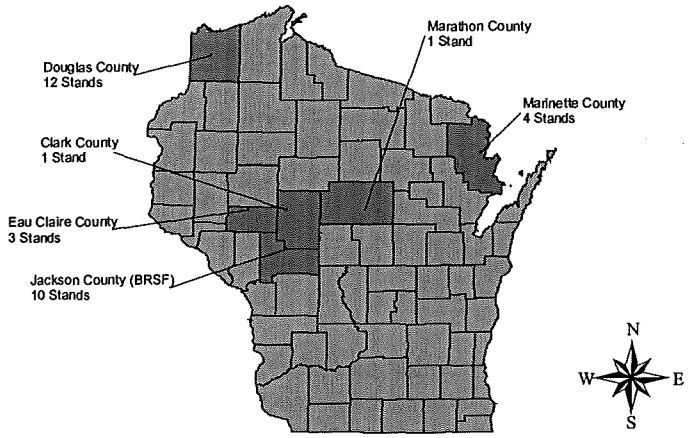
Incidence and Severity of Collar Rot, caused by *Sphaeropsis sapinea,* affecting Red Pine and Jack Pine Plantations in Central and Northern Wisconsin

(Mark Guthmiller and Sally Dahir, WI DNR Forest Health Protection-Fitchburg)

Introduction

Heavy mortality to young red and jack pine plantations has been reported periodically since the early 1970's. Recent mortality was once again reported and observed in 1998 and 1999 at various locations in Wisconsin. The primary cause of mortality has been attributed to collar rot caused by the fungus *Sphaeropsis sapinea* (syn. *Diplodia pinea).* An intensive survey of red and jack pine seedling/sapling plantations, with apparent heavy mortality, was carried out over six counties in central and northern Wisconsin.

1999 Collar Rot Survey Locations



Objectives

The objectives of this survey were to 1) determine the incidence of seedlings showing various disease symptoms within a stand, 2) determine the incidence of mortality and residual stocking within a stand, 3) confirm the cause(s) of mortality, 4) assess vegetative competition, and 5) assess rooting conditions of dead trees.

Field Methods

Thirty-one stands in 6 counties were selected based on observations of stands having apparent heavy mortality including 24 red pine stands and 7 jack pine stands. Ten circular 50th acre plots were surveyed for symptoms at each stand location. Two or more symptomatic trees were sampled from each of 10 plots for laboratory diagnosis. Tree disease symptom data and samples collected included; trees all dead, top dead, branch dead, and shoot dead.

Additional information gathered included location, site prep and planting methods, pre-plant herbicide use, rooting condition of dead trees, and competition by grass and woody vegetation.

Field Results

Symptoms Observed:

The percent of symptoms observed for all sites combined is shown in the chart below. The percent of symptoms observed is based on data collected in the 10 circular plots at each stand (310 total plots). An average of 13% of the trees were dead. The averages for other symptoms observed included 6% percent with dead tops, 7.2% had dead branches, and 15.6% of the trees had one or more dead shoots present.

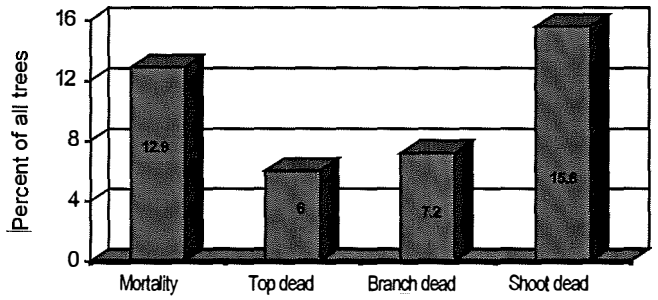


Figure 1. Symptoms observed (All sites combined)

Site Specific Mortality:

The percent of trees dead varied from 0-46% (Table 1). The average mortality for all sites, as mentioned above, was 12.9%. This variability in mortality between stands is probably due to field staff observations of what was considered heavy mortality. Observations from a distance may give the appearance of mortality when indeed symptoms observed at a closer inspection may have been top kill or branch mortality.

The heaviest mortality (46%) occurred in a red pine plantation on the Black River State Forest in Jackson County. A red pine plantation in Marathon County had 34% mortality. This particular site, interestingly, had the top 6-8" of topsoil removed on approximately 9/10th of the plantation. Heavy mortality was evident where the topsoil had been removed. In the non-disturbed areas of the plantation, dead trees were scarce. Interestingly, only 1% of the naturally regenerated jack pine was dead at this site, possibly indicating a much greater tolerance for drought conditions or a greater ability to resist disease under the same conditions as red pine. Another possibility is that the red pine was exposed to *S. sapinea* prior to planting and existed in the tissue as a latent pathogen until conditions were such for disease development to occur.

Table 1. Range of percent mortality between plantations by county.

County	No. of Stands	Range of % Mortality	Average % Mortality
Clark	1	13	13
Douglas	12	5-17	11
Eau Claire	3	7-28	18
Jackson[2]	10	0-46	12
Marathon[3]	1	34	34
Marinette	4	4-16	10

[2] Jackson County refers to sites listed on charts in this document as Black River State Forest sites.
[3] Marathon refers to the site listed as Wausau on charts in this document.

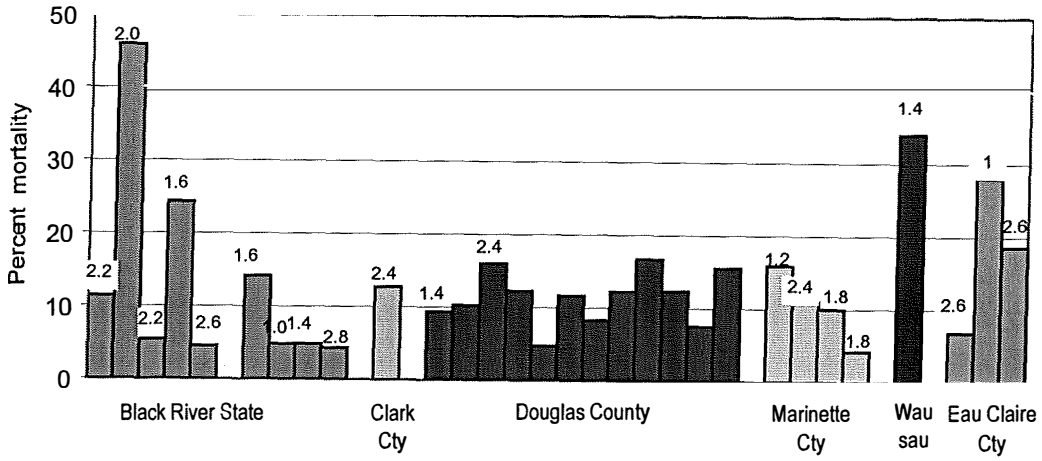


Figure 2. Percent mortality by stand (root ratings labeled on top of bar).

Root Ratings:

Root ratings were taken at 20 of the 31 stands using a subjective rating system of 1= Very Poor, J-rooted, 2= Poor, and 3= Adequate (Figure 2). At each plantation 5 dead trees were dug up and roots rated. Root ratings varied from 1.0- 2.8. The average for all sites combined was poor at 1.9. Using 19 out of the 20 sites (the site with the heaviest mortality had a rating of poor, 2.0 and was not included) a correlation between root rating and mortality was computed. There appears to be a significant correlation of -0.35 between rooting condition and mortality (Fig.3). A larger sample size and sampling apparent healthy trees would be recommended if similar surveys are undertaken.

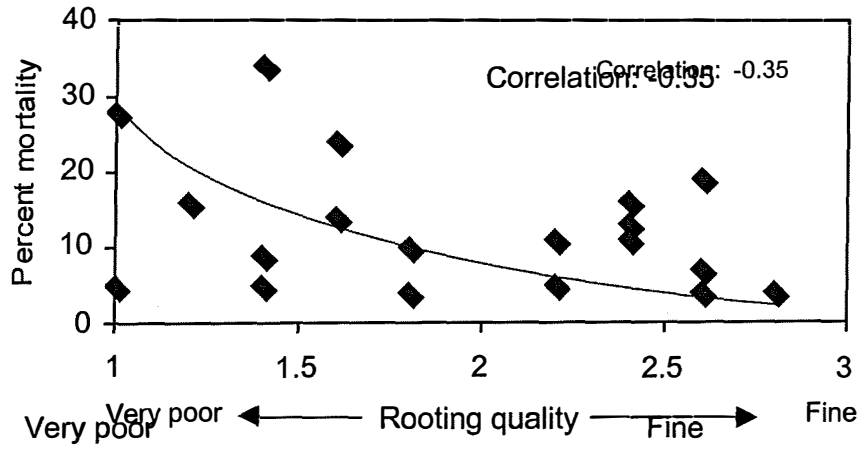


Figure 3. Correlation between percent mortality and rooting quality

Vegetative Competition:

Competing vegetation was rated at each plot and averaged for each stand using a subjective scale of low, medium, and high. This rating included both woody and grass competition. All but two of the sites were rated as having medium to heavy competition (Fig. 4). The two sites with low competition included the plantation in Marathon County where the top 6-8" of topsoil had been removed and a site in Jackson County that also had the lowest (5%) mortality of all the stands in Jackson County.

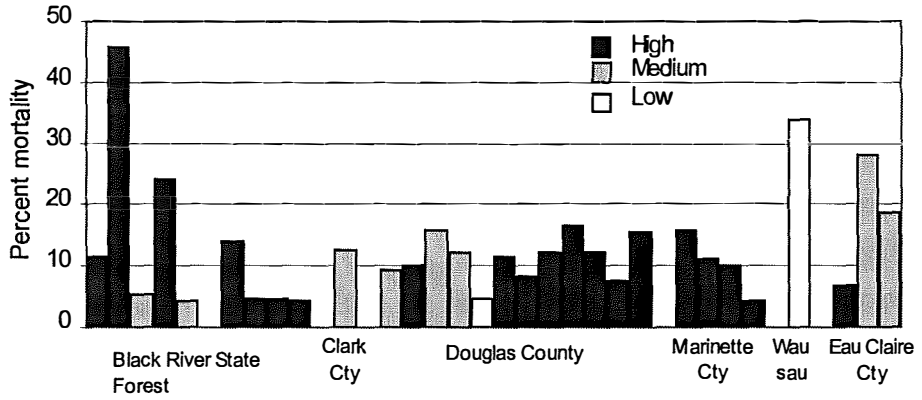


Figure 4. Percent mortality associated with levels of vegetative competition

Residual Stocking Levels:

Residual stocking levels were looked at in the two following ways: 1) residual trees with no symptoms and 2) residual trees including symptomatic (not dead) trees (Fig. 5). Residual stocking levels for non-symptomatic red pine plantations ranged from 110-830 trees/acre and 180-900 trees/acre when live symptomatic trees were included. Residual stocking levels for non-symptomatic jack pine plantations ranged from 180-760 trees/acre and 215-850 trees/acre when live symptomatic trees were included. Four hundred trees/acre is considered under stocked for red pine seedling/saplings and between 800-1200 trees/acre ideal stocking for jack pine (Wisconsin DNR Silviculture and Forest Aesthetics Handbook). Residual stocking levels, with the exception of a couple plantations, are acceptable if one includes symptomatic trees. The potential does exist for under stocking in many of the stands if disease symptoms were to reflect possible mortality in the future.

Lab Methods

A minimum of two samples from each of ten plots per plantation were gathered and stored in cold storage for laboratory diagnosis. Samples gathered included the various categories of symptoms observed. These samples were examined for the presence of *S. sapinea*. Black pycnidia were extracted from tree tissue and squashed on a microscope slide and examined for spores. Observation of spores was required for positive

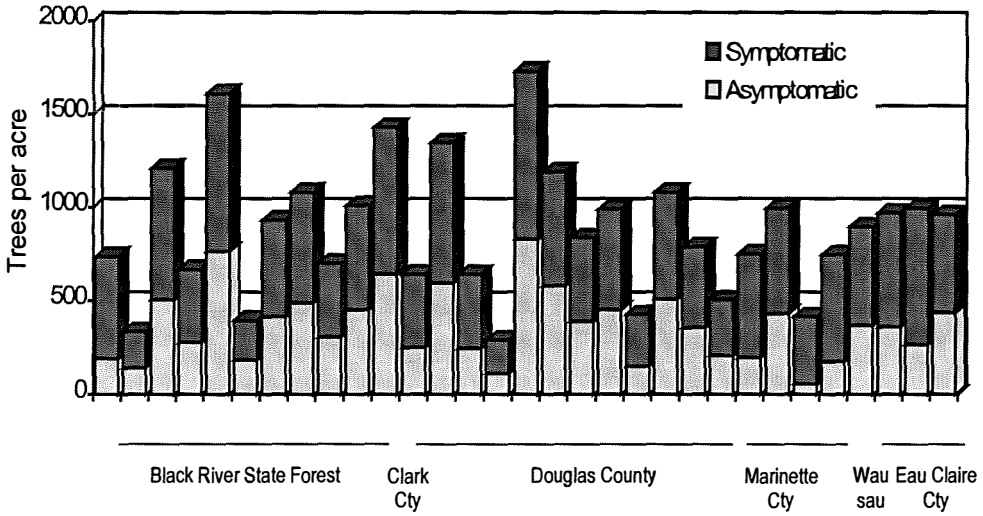


Figure 5. Residual stocking levels at each stand

recording in the data. These samples were also observed for Armillaria root rot and insect damage. A sample had to have a mycelial fan present to be recorded as positive for Armillaria. The presence of insects as well as signs of insect damage was recorded when observed.

Lab Results

Laboratory samples were diagnosed as explained above and causal agents related back to the percent of field mortality observed (Figure 6). The percent mortality related only to *S. sapinea* ranged from 1-21% in 22 of the 31 stands. The percent mortality related only to Armillaria ranged from 1-9% in 14 stands and the percent mortality related to both the presence of *S. sapinea* and Armillaria ranged from 1-14% in 17 stands.

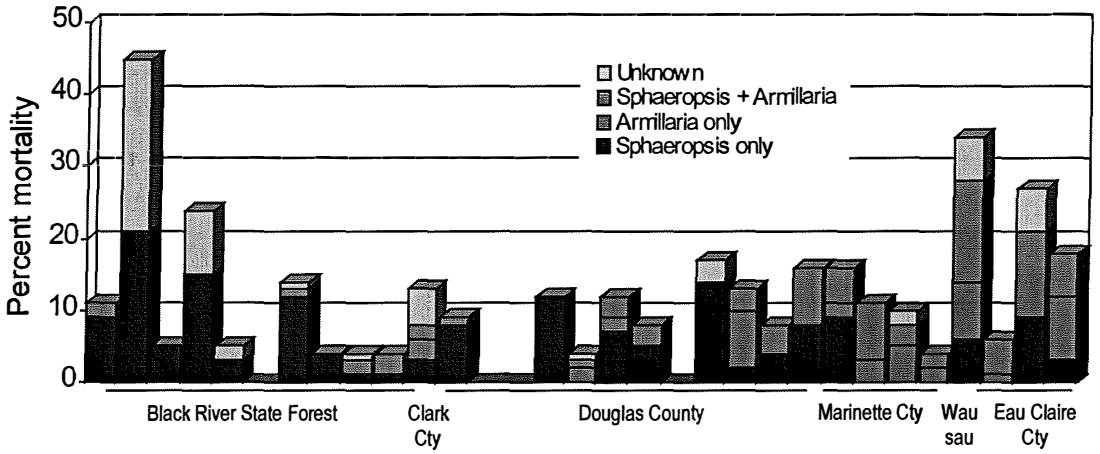


Figure 6. Cause of mortality in percent based on laboratory diagnosis

In 11 stands, undetermined cause of mortality ranged from 1-24%. S. sapinea was associated with mortality in 27 of the 31 stands. The remaining four stands did not have mortality present in our survey plots. Armillaria was associated with mortality either alone or in the presence of *S. sapinea* in 20 of the stands.

Insect Damage Noted:

Observations of insect damage were recorded while evaluating the lab samples. Thirteen percent of the "all dead" tree samples had insect damage present. Only 5% of the "all dead" trees sampled, with no S. sapinea associated, had insect damage present. The insect damage appeared to be from flat head borers, bark beetles and turpentine beetles.

Conclusions

S. sapinea was present in all the stands surveyed that had mortality. It appears to be the primary cause of mortality in these stands. Armillaria was associated with mortality in 20 of these stands and may be a contributing or sole factor in the cause of some of the tree mortality. Insects were not a major influence in tree mortality with only 13% of "all dead" lab samples having insect damage present. The quality of the root systems for all sites combined average a poor rating and is a likely contributor to mortality at some sites. Another contributing factor in tree mortality is likely the grass competition at many of these sites. The majority of the stands averaged a medium to heavy rating. Lastly, the residual stocking levels at many of these stands appears to remain adequate even with apparent heavy mortality present. A couple of the stands did appear to be under stocked at current levels and many of the stands are poised for heavy mortality in the future based on disease symptoms observed.

Recommendations

Since *S. sapinea* is primarily a disease of trees under stress. Cultural practices that reduce unnecessary stresses such as proper planting to avoid J-rooting and grass control at pre and/or post planting may substantially reduce mortality on these poor quality sandy sites.

Site	County	Compartment	Stand/Plantation	Legal Discription
1	Jackson	17	8	T22NR3W24NW
2	Jackson	17	10	T22NR3W24NW
3	Jackson	17	9	T22NR3W24NW
4	Jackson	35	9	T22NR2W13SE
5	Jackson	38	9	T22NR2W19NW
6	Jackson	38	6	T22NR2W19NE
7	Jackson	39	16?	T22NR2-3W25
8	Jackson	40	8	T22NR2W20-29
9	Jackson	43	11	T22NR2W29-32
10	Jackson	30	4	T22NR3W32
11	Clark	Rock Dam		T26NR4W22-23
12	Douglas			T44NR11W26NWNE
13	Douglas			T44NR11W25SWSE
14	Douglas			T44NR11W25NWNW
15	Douglas			T45NR10W15NENE
16	Douglas			T45NR11W1SESE
17	Douglas			T45NR10W3SWSE
18	Douglas			T45NR10W11NWNW
19	Douglas			T44NR10W113NENE
20	Douglas			T44NR9W7SWNW
21	Douglas			T44NR10W1SESW
22	Douglas			T45NR10W20SWSE
23	Douglas			T45NR10W30SWSE
24	Marinette	2	13/432	T32NR18E9NE
25	Marinette	3	P20&P21/423	T32NR18E4NWSW-5NESE
26	Marinette	9	P15&P16/422	T32NR18E22N1/2
27	Marinette	7	P12/421	T32NR18E12SE
28	Marathon		Gate of Heaven Site	T27NR7E2NESW
29	Eau Claire			T27NR6W35SWSW
30	Eau Claire			T26NR5W23NESW-NWSE
31	Eau Claire			T26NR6W10S1/2NE

Silvicultural Alternatives which Promote Rapid Growth and Survival of Butternut

(Sally Dahir, WI DNR Forest Health Protection-Fitchburg)

Introduction and Background

Wisconsin currently has the greatest volume of butternut (*Juglans cinearea*) in the North Central Region and has been a leading producer of butternut lumber in the past . In the last 10-15 years, however, there has been a dramatic decrease in the number of live butternut in the state. A major factor in this decline is an increase in cankers caused by the fungus *Sirococcus clavigignenti-juglandacearum* (Figure 1). Tisserat and Kuntz (1984) surveyed a plantation in Wisconsin in 1976 and 1983, and noted that the incidence of cankers increased from 5% to 76% in just 5 years. In a study by Cummings-Carlson (1993) of c. 1,400 butternut trees in 32 counties in Wisconsin, 91% of trees were found to be infected. According to Sinclair (1987), not only are butternut of all ages and sizes affected by the disease, but cankered trees are found both in mixed and pure stands, and on dry infertile ridgetops as well as moist, fertile bottomlands. This disease not only spreads quite rapidly but, once infected, most trees will die. In order to maintain butternut as a viable component of Wisconsin forests, efforts must be focused on perpetuating the species. Two major objectives in managing this disease are 1) the establishment of natural regeneration which is disease resistant and 2) promoting the growth rate of saplings to a size where they may escape the girdling effects of cankers and produce viable seed.

Figure 1. Typical elliptical canker revealing black discoloration of cambium.

The second objective was the major focus of this study, not only to maintain a viable population of the species but also to gain a better understanding of the silvicultural requirements of butternut. In 1994, a focus fund project was initiated to compare the growth potential of butternut on dry-mesic and mesic habitat types and under various sizes of canopy opening. Two sites (30 plots) were chosen in Menominee County, Wisconsin. Half of the plots (15) were located on a mesic habitat type, ATFD (*Acer saccharum-Tsuga canadensis-Fagus grandifolia/Dryopteris spinulosa*), and the other 15 on a dry-mesic site with both AQVb(Ha) (*Acer-saccharum-Querqus rubra/Vibernum acerifolium, Hamamelis virginiana* variant) and PMV(Q) (*Pinus strobus/Maianthemum canadense-Vaccinium angustifolium, Quercus elipsoidalis* variant) habitat types. Four of the dry-mesic plots were PMV(Q) (a 1-acre plot and three 2-acre plots) and the remaining 11 were all AQVb(Ha). Also, in order to better delineate spatial requirements for optimum growth, seedlings were planted in five different sizes of canopy opening: 0.03 acre, 0.25 acre, 0.5 acre, 1 acre, and 2 acres. Three plots were established for each habitat group-gap size combination, for a total of 30 plots.

Plots were located in south central Menominee County in northern hardwood forest type. Major associated species included sugar maple, beech, red oak and yellow birch on the mesic site and red oak, red maple, aspen and white pine on the dry mesic plots. Approximately 1,200 butternut seedlings were planted in 1994 at a 10 x 10 foot spacing. Plantings were concentrated in the center of the openings to avoid excessive shading from bordering canopy trees. A replanting was done in 1995 due to high initial mortality. The seedlings were measured annually from 1994-1999 (with the exception of 1998). Diameter at the base and height were recorded and presence of cankering noted. Future data collection will continue at 5 year intervals until the year 2015.

This paper summarizes the data collected from 1994-1999. To avoid ambiguity as to the first planting date (due to replanting in 1995), a four-year timespan (1995-1999) was used for data analysis. There has not been any attempt to control vegetation as yet and many plots, especially on the ATFD and AQVb(Ha) sites, had significant amounts of competing vegetation, largely aspen saplings, blackberry bushes and bindweed.

Table 1. Average height and diameter growth are reported for the years 1995 to 1999 on three habitat types and 5 gap opening sizes. The number of seedlings in each group is given in parentheses. For each gap size, the significance of an ANOVA which compared mean height and mean diameter between the habitat types is also reported.

Gap Size (acres)	Height Growth (cm)				Diameter Growth (mm)			
	PMV(Q)	AQVb(Ha)	ATFD	*p*-value	PMV(Q)	AQVb(Ha)	ATFD	*p*-value
0.03	-	8.1 (23)	57.5 (32)	<0.0001	-	1.1	5.7	<0.0001
0.25	-	88.7 (37)	142.1 (38)	0.001	-	7.7	16.2	<0.001
0.5	-	119.8 (96)	140.3 (107)	0.034	-	15.6	18.2	0.109
1	6.7 (29)	69.7 (80)	94.5 (120)	0.002	0.6	6.0	8.1	<0.0001
2	15.2 (83)	-	82.7 (117)	<0.0001	2.2	-	7.0	<0.0001
Total	13.0 (112)	88.7 (236)	104.5 (414)	<0.0001	1.8	10.0	11.0	<0.0001

Results

There was a distinct difference in growth rates and survival of seedlings between the dry-mesic and mesic types, as well as a significant difference between the two dry-mesic habitat types, AQVb(Ha) and PMV(Q) (table 1). Both diameter and height growth were significantly higher on the mesic ATFD type and lower on the dry-mesic sites, especially the PMV(Q) plots. Growth rates also differed significantly between the various canopy opening sizes with the highest growth rates occurring on the plots in half acre openings and the lowest in the 0.03 acre opening (table 1). Mortality rates were lowest on the ATFD habitat type and on the 0.03 acre plots.

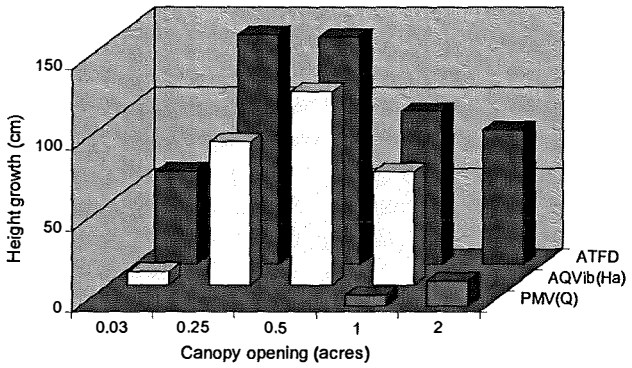


Figure 2. Average total height growth from 1995-1999 on 3 habitat types and 5 canopy opening sizes

Height growth between 1995 and 1999 (Figure 2) averaged 86.1 cm or 21.5 cm/year on all plots. Height growth was significantly higher ($F=75.4$, $MSE=4210$, $p<0.0001$) on the mesic sites (mean of 104.5 cm) than on the dry-mesic sites (averaging 62.9cm) and also significantly higher ($F=101.4$, $MSE=3644$, $p<0.0001$) on the ATFD (104.5cm) and AQVb(Ha) plots (mean = 88.7cm) than on the PMV(Q) plots (averaging only 13cm).

Gap size also seemed to make a significant difference in height growth rates (Table 1). Both AQVb(Ha) and ATFD show much higher growth rates in the medium size gaps, 0.5 acre and 0.25 acre. Whereas, there is almost no difference between the 0.25 and 0.5 acre openings on the mesic site, height growth rates are substantially higher on the 0.5 acre site on the AQVb(Ha) plots. For both types, height growth is much lower in the 0.03 acre gaps than in larger size openings.

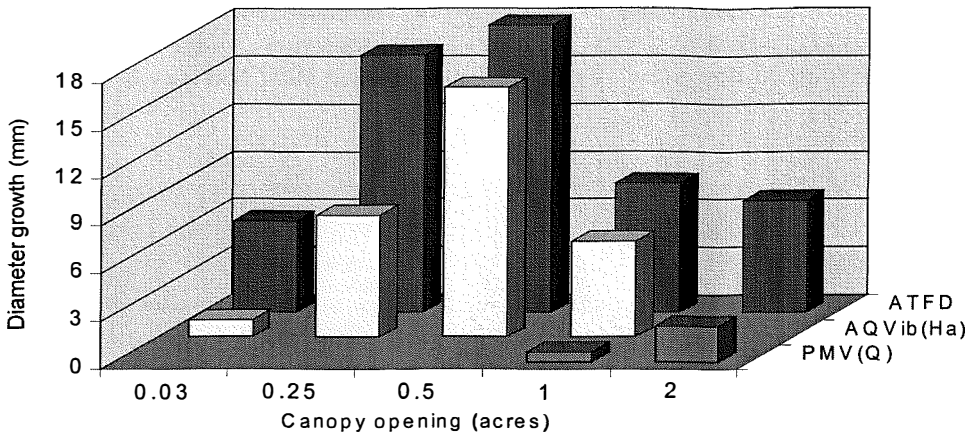


Figure 3. Diameter growth was greatest on ATFD habitat type and in 0.5 acre canopy opening.

Diameter growth between 1995 and 1999 (Table1, Figure 3) averaged 9.3 mm or 2.3 mm/year on all plots. As with height, diameter growth rates were significantly higher ($F=28.4$, $MSE=89.7$, $p<0.0001$) on the mesic site (mean of 11.0 mm) than on the dry-mesic sites (averaging 7.2mm) and also higher ($F=45.4$, $MSE=83.1$, $p<0.0001$) on the ATFD and AQVb(Ha) plots (mean = 10.0 mm) than on the PMV(Q) plots (averaging only 1.8mm).

Diameter growth was highest in the half-acre openings. Again there was less difference between the 0.25 and 0.5 acre plots on the mesic habitat type than on the dry-mesic site. Diameter growth rates were also much lower on the 0.03 acre openings.

Survival rates reflect the same trend as growth rates with highest survival on the mesic sites and lowest on the dry-mesic (Figure 4). Overall mortality between 1995-1999 averaged 36.5% on all plots with an average 28.0% on the mesic plots and 43.2% on the dry-mesic sites. This difference was significant with $p<0.005$ ($F=9.91$, $MSE=174.3$). Again, PMV(Q) had significantly higher mortality (50.2%) than either AQVb(Ha) (40.6%) or ATFD (28.0%).

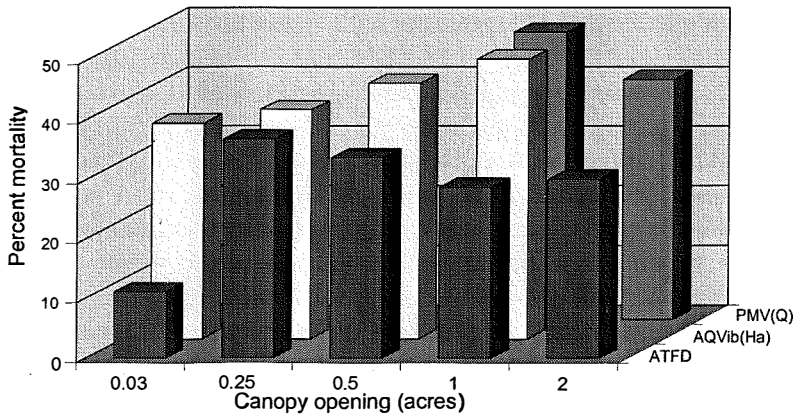
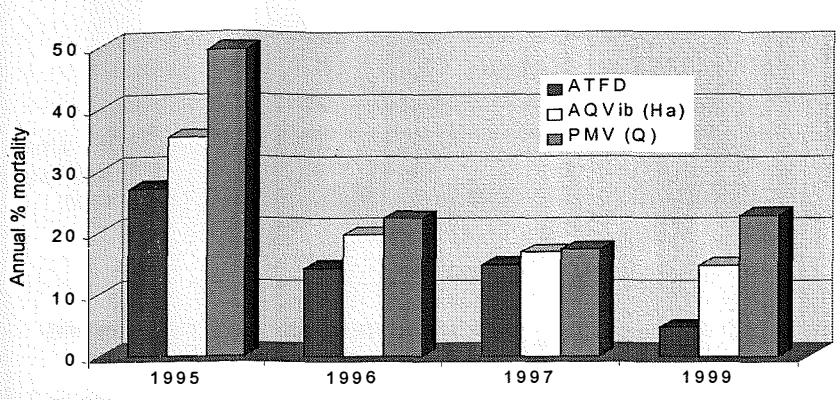


Figure 4. Mortality was highest on the driest site and lowest on the 0.03 acre plots.

Within each habitat type, mortality varies monotonically with the size of canopy opening. The trend, however, is increasing for AQVb(Ha) and decreasing with ATFD and PMV(Q). The only consistent relationship between mesic and dry-mesic sites is a significantly lower mortality ($p=0.1$) on the 0.03 acre plots compared to all larger plots combined, averaging 23.6% and 35.2%, respectively.

Mortality rates declined (Figure 5) from year to year on all habitat types, with the exception of PMV(Q) in 1999, and in all gap sizes. Unusually high mortality 33.8% from 1994 to 1995 (with subsequent replanting) was followed by 17.4% in 1996, 15.8% in 1997 and only 8.7% from 1996-1999.



Fgure 5. Mortality has decreased every year since 1995 except on the poorest site.

Discussion

Butternut is classified as an intolerant species. It seems to grow best on mesic sites where it is found most commonly in association with hardwood species such as sugar maple, yellow birch, basswood and beech. Seedlings do not survive well under heavy competition or shading from above. It can grow quite rapidly under the right conditions but these have not been well documented. Under optimal growing conditions, butternut trees that can survive to age 20 will be capable of producing seed and perpetuating the species.

The results of this study demonstrate that butternut not only has better height and diameter growth on more mesic sites, but also higher survival. Although faring moderately well on the AQVb(Ha) site, seedlings displayed much lower height and diameter growth on the PMV(Q) habitat type. PMV(Q), typically found on sands and loamy sands, is both drier and more nutrient poor than AQVb(Ha), which occurs most often on sandy loams. ATFD sites are both wetter and more nutrient-rich.

The relationship of canopy opening size and growth rates is more complex. On the 3 larger opening sizes (0.5, 1, and 2 acres), seedlings were planted in a 0.1 acre plot in the center of the opening. With a buffer of from 80 to 220 feet between the gap border and the plot, this would effectively eliminate side shade from surrounding canopy trees as a limiting factor in growth. A possible cause of the decrease in growth rates in openings larger than 0.5 acres, may have been the amount of hardwood sprouting and herbaceous competition which was especially thick and tall in the larger openings. Both height and diameter growth rates were substantially lower in the 0.03 acre opening. This size of gap would be equivalent to a single tree canopy gap in a mature forest and should quickly close over as a result of crown expansion of bordering canopy trees. With a buffer distance of only 6-16 feet between the plot border and canopy trees, the amount of light reaching these seedlings is negligible and probably accounts for the slow growth rates. Survival on these essentially understory plots, however, was higher than on any of the larger openings. This may also have been related to competition levels, since there was little shrub or herbaceous vegetation growing on these shaded plots.

If growth rates continue to be high, especially on the more mesic plots, with continually falling mortality, there is a good chance that several trees will reach reproductive age. Competition control will certainly improve both growth rates and survival. The presence/absence of heavy competition on certain plots may certainly have been a factor in determining growth rates as well as mortality. Herbicide

treatment is being planned for the year 2000. Subsequent measurements will better delineate the effect of this treatment.

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